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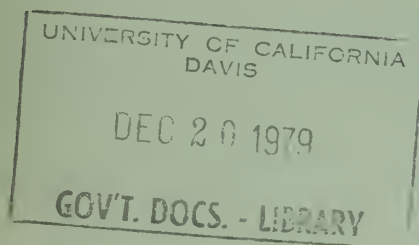
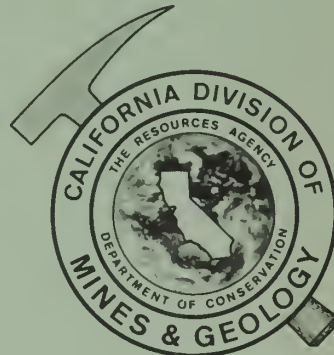
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AGGREGATES IN
THE GREATER LOS ANGELES AREA,
CALIFORNIA

1979

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SPECIAL REPORT 139



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Special Report 139

AGGREGATES IN THE GREATER LOS ANGELES AREA, CALIFORNIA

By

James R. Evans, Thomas P. Anderson, Michael W. Manson,
Randall L. Maud, William B. Clark, and Donald L. Fife

1979

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ABSTRACT

Seventy-one aggregate-producing sites concentrated in 10 separate production districts supply aggregate for the area within a 60 mile radius of the downtown Los Angeles Civic Center. This area is populated by some 10 million inhabitants. In 1975, almost 45 million tons of aggregate were utilized in this area as a basic construction material. It was sold at pit site prices ranging from \$1.50 to \$2.50 per ton, but was delivered to the use-site at substantially higher prices because of transportation costs.

Analyses from each of the 71 production sites involved: a study of geologic factors that formed the aggregate deposit; interviews with company representatives; a study of company and government documents; and a volumetric determination of reserves and resources mined and those remaining at each site. Aggregate reserves and resources were quantitatively determined. Reserves represent material believed to be acceptable for commercial use that exists within property boundaries owned or leased by an aggregate producing company, and permission granted allowing extraction and processing by the proper authorities. Resources include similar material existing on company owned/leased land, but cannot be mined either because no use permit has been granted allowing extraction or because current technological or economic conditions prevent development. Reserves within the study area are calculated to be about 1.3 billion tons of aggregate while resources are calculated to be about 1.9 billion tons.

Five major factors affecting supply-demand relationships are discussed and these include: environmental concerns and existing land uses; economics; transportation; geologic considerations; and use of substitute materials. A forecast based upon these factors and a steady state depletion of aggregate at the rate of about 43.4 million tons per year, indicates that the reserves within the study area will become depleted about the year 2005. If the identified resources are added to the reserves, it will postpone the depletion date to about the year 2052.

Because aggregate reserves and production vary considerably between production districts, it is anticipated that each will exhaust its reserves at different times in the coming years. When a particular district has exhausted its reserves, this will cause an increased demand for aggregate from the adjacent districts, thus accelerating their rates of depletion. The study shows that major patterns of aggregate supply will shift from the current major production districts to others which are presently producing less, or to other deposits not presently planned for. As this occurs, solutions will be needed for resulting problems related to transportation, storage facilities, and environmental and reclamation considerations.

Proper steps to ensure an adequate supply of low-cost aggregate should be taken by appropriate government agencies in order to keep existing districts in production as long as possible. Because of the regional nature of this problem, the various planning agencies for the area should work together toward insuring that this goal is achieved while at the same time not compromising environmental or land-use considerations. Planning should include: zoning of land for future aggregate extraction; approval of extraction permits within a reasonable time frame; and development of a government climate that allows for proper geologic exploration for new deposits and encourages the necessary capital investment for development.

AGGREGATES IN THE GREATER LOS ANGELES AREA, CALIFORNIA

by

James R. Evans,¹ Thomas P. Anderson,¹ Michael W. Manson,¹
Randall L. Maud,¹ William B. Clark,¹ and Donald L. Fife¹

INTRODUCTION

Scope and Purpose

Aggregate is the basic filler material in all uses of concrete: construction of homes, non-resident buildings, dams, bridges, highways and other structures common to our society. The area within a 60-mile radius of downtown Los Angeles Civic Center (figure 1) is the largest producer and consumer of aggregate in the United States.

In past years, the various population centers within the greater Los Angeles area, which include a total of some 10 million inhabitants, have been served from local sources of high quality aggregate material at relatively low costs. This is because aggregate is a bulk commodity with a low unit value at the quarry site, and the delivered price is largely dependent upon transportation costs. As urban expansion continues in the greater Los Angeles area in coming years, so will the use of aggregate for construction and eventually, additional sources of aggregate will be needed. However, urban expansion, especially within a confined area (e.g., Los Angeles basin), also results in greater competition for land use, which could result in a negative effect on the local aggregate supply unless wise land use planning is undertaken.

To date, this report is the result of the most detailed aggregate resource study ever undertaken in California. The report is intended to furnish the needed data to local government agencies, land planners, citizens, and aggregate producers of the greater Los Angeles area in order that they may develop land use plans that will allow an orderly and adequate supply of locally mined, low cost aggregate material to continue under proper technological and environmental conditions.

Data Gathering

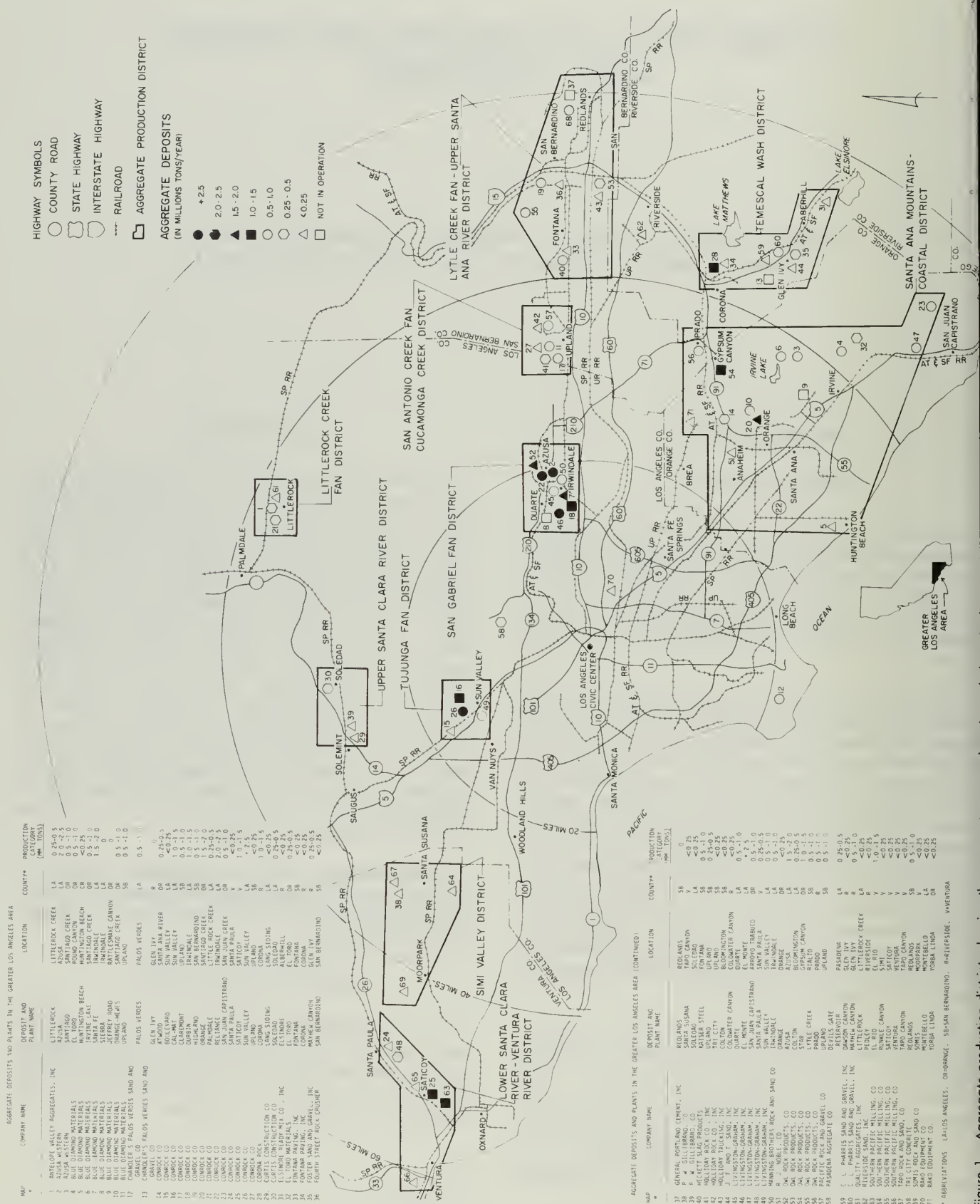
The data gathering phase of the study leading to this report lasted from July 1975 until June 1976. In order to generate a uniform, up-to-date, and complete data base for this report, CDMG staff made field visits to each aggregate processing plant and deposit in the study area and prepared a detailed, itemized report for each operation. These reports included data on ownership, history of plant operation and production, marketing, geology of the deposit, analysis of the reserves and resources, mining extraction methods, plant processing methods, transportation used, land use, and environmental considerations. Published material on aggregate processing plants was assembled into a central file. The study required confidential information from many of the aggregate producing companies; all the information that can be made public is on file and may be consulted in the Los Angeles District Office of the Division of Mines and Geology.

During this study, reserves and resources of aggregate and their rates of depletion were determined only for those lands that are now owned or under control of aggregate producing companies.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the aid and full cooperation of office and field staff of the aggregates industry, and government staff of several cities and the five counties involved: Los Angeles, Ventura, San Bernardino, Riverside, and Orange. The Southern

¹ Geologist, CDMG



* ABBREVIATIONS LA=LOS ANGELES, OR=ORANGE, SR=SAN BERNARDINO, R=RIVERSIDE, V=VENTURA

California Rock Products Association was an additional source of helpful information. Our study was possible only because the aggregate companies allowed the use of their confidential data. A special word of thanks goes to the U.S. Bureau of Mines; without their cooperation and funding the study would have been most difficult and long delayed.

AGGREGATE INDUSTRY

Significance of the Industry and Its Products

California is the nation's leading producer of aggregates, and the greater Los Angeles area is the nation's leading producer for its geographic size (figure 1). In terms of California's mineral products, the value of the aggregates industry is second only to that of the petroleum industry. Continuing a trend of many years, sales of aggregate in California from 1970 to 1975 have been 104 m.t. (million tons) or more per year. Sales in the greater Los Angeles area were about 37 m.t. or more in this same period, averaging about $\frac{1}{3}$ of the California total (table 1). Throughout this report the terms "sales" and

Table 1. Tons of aggregate sold in the greater Los Angeles area from 1960 through 1975, compared to total sales in California (short tons). Data from U.S. Bureau of Mines, and California Division of Mines and Geology.

YEAR	AGGREGATE SALES IN CALIFORNIA			RANK IN UNITED STATES	AGGREGATES SOLD IN THE GREATER LOS ANGELES AREA	% OF CALIFORNIA SALES
	SAND & GRAVEL	CRUSHED STONE	TOTAL			
1960	86,684,000	10,660,000	97,344,000	1	30,751,000	31.6
1961	109,128,000	11,483,000	120,611,000	1	38,302,000	31.7
1962	106,578,000	13,061,000	119,639,000	1	43,912,000	36.7
1963	111,059,000	14,900,000	125,959,000	1	42,624,000	33.8
1964	111,513,000	15,510,000	127,023,000	1	43,368,000	34.1
1965	116,964,000	16,274,000	133,238,000	1	43,517,000	32.6
1966	119,287,000	15,440,000	134,727,000	1	48,681,000	36.1
1967	114,699,000	14,273,000	128,972,000	1	41,318,000	32.0
1968	123,044,000	14,815,000	137,859,000	1	47,094,000	34.1
1969	122,857,000	16,211,000	139,068,000	1	44,619,000	32.1
1970	136,407,000	13,778,000	150,185,000	1	47,289,000	31.5
1971	113,015,000	20,401,000	133,416,000	1	46,083,000	34.5
1972	115,073,000	17,463,000	132,536,000	1	46,957,000	35.4
1973	115,331,000	22,755,000	138,086,000	1	50,849,000	36.8
1974	103,005,000	22,182,000	125,187,000	1	41,053,000	32.8
1975	88,445,000	15,779,000	104,224,000	1	37,514,000	36.0
TOTAL	1,793,089,000	254,985,000	2,048,074,000		693,931,000	33.9

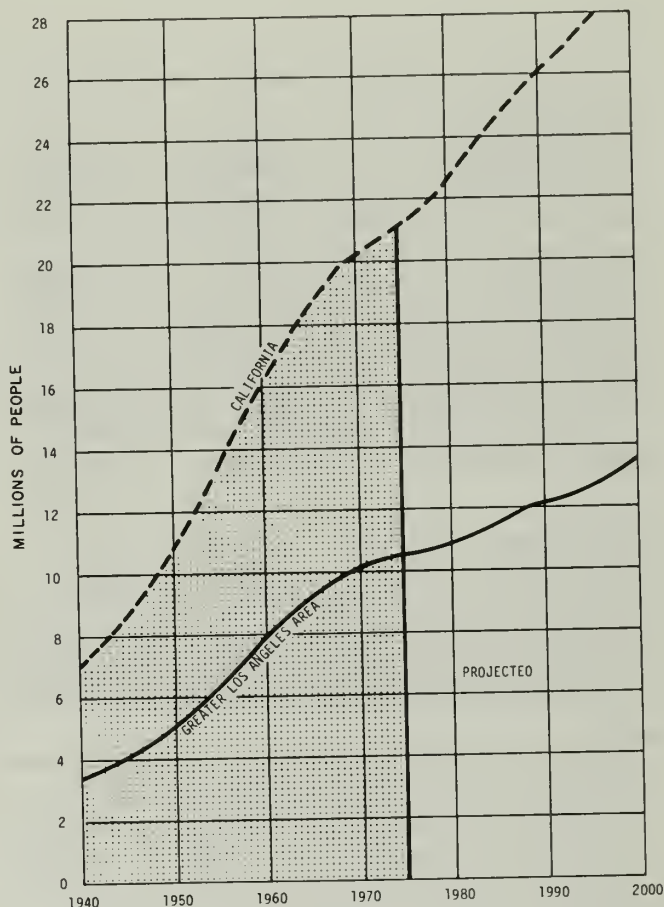


Figure 2. Population growth in the greater Los Angeles area compared with California.

which were active in 1975. For convenience, and in order to describe supply and demand problems in better terms, 10 production districts have been identified for discussion purposes throughout this report. Insofar as possible, the districts were distinguished on both geologic and geographic bases. Appendix 1 shows the location of the concrete batch plants and asphalt concrete batch plants in the study area.

Uses and Prices of Aggregates

Aggregates are an essential material for building and construction industries. The terms "aggregate" or "aggregates", used in this report, mean materials composed of natural or crushed, hard, sound, and durable particles of unreactive minerals. Aggregates are carefully graded into certain size categories so they may be recombined according to required specifications into various size mixes for different purposes. Material making up aggregates should be clean and free from clay-like material, organic matter, and chemical salts. As used in aggregates, "gravel" refers to material composed of particles larger than one-quarter inch in longest dimension; "sand" is particles smaller than one-quarter

"production" will be used interchangeably because they show very little difference. The data in Figure 2 and Table 1 indicate consumption of aggregates in the study area and averages about 4 tons per person. However, in 1974 and 1975 due to a drop in building and construction and a decrease in freeway construction, tonnage sales have dropped from about 44.6 m.t. in 1971 to about 38 m.t. in 1975 (table 2 and figure 3). In 1975 the average selling price of aggregates at the plant site throughout the area was about \$2 per ton. The total real value of aggregates in the area's economy, however, is much greater, as will be explained later in this section.

The greater Los Angeles area has always been well served with aggregate from conveniently located supplies of high-quality, low cost aggregate raw materials. Figure 1 shows the location of the 71 companies' operations

Table 2. Total building and construction in the Los Angeles five-county area* 1971-1975.

	1971	1972	1973	1974	1975	PERCENTAGE CH 1972-75 197	
Residential building:							
Single dwellings.....	\$ 896,370,000	\$1,086,371,000	\$1,015,053,000	\$ 783,872,000	\$1,268,399,000	+ 16.8	+ 6
Multiple dwellings.....	816,764,000	1,074,939,000	992,394,000	519,653,000	374,953,000	- 65.1	- 2
Total new residential.....	\$1,713,134,000	\$2,161,310,000	\$2,007,447,000	\$1,303,525,000	\$1,643,352,000	- 24.0	+ 26
Alterations & additions.....	146,454,000	165,022,000	161,576,000	204,046,000	246,731,000	+ 49.5	+ 20
Total residential building	\$1,859,588,000	\$2,326,332,000	\$2,169,023,000	\$1,507,571,000	\$1,890,083,000	- 18.8	+ 23
Nonresidential building:							
New commercial.....	\$ 648,433,000	\$ 855,208,000	\$ 727,121,000	\$ 656,513,000	\$ 633,019,000	- 26.0	- 3
New industrial.....	185,851,000	266,915,000	397,197,000	335,638,000	246,364,000	- 7.7	- 26
Other new nonresidential.....	574,486,000	497,163,000	442,784,000	410,508,000	476,124,000	- 4.2	+ 16
Alterations & additions.....	145,173,000	143,529,000	173,016,000	179,838,000	175,352,000	+ 22.2	- 2
Total nonresid. permits.....	\$1,553,943,000	\$1,762,815,000	\$1,740,118,000	\$1,582,497,000	\$1,530,859,000	- 13.2	- 3
Total building permits.....	\$3,413,531,000	\$4,089,147,000	\$3,909,141,000	\$3,090,068,000	\$3,420,942,000	- 16.3	+ 10
Non-permit building.....	144,158,000	200,457,000	184,082,000	277,841,000	265,948,000	+ 32.7	- 4
Total building.....	\$3,557,689,000	\$4,290,685,000	\$4,094,171,000	\$3,367,909,000	\$3,686,890,000	- 14.1	+ 9
Engineering construction ".....	493,286,000	485,966,000	556,460,000	538,508,000	417,272,000	- 14.1	- 22
Total building & construction	\$4,050,975,000	\$4,776,651,000	\$4,650,631,000	\$3,906,417,000	\$4,104,162,000	- 14.1	+ 5
No. of new housing units:							
Single dwellings.....	38,156	44,138	37,649	24,738	31,903	- 27.7	+ 29
Units in multiples.....	61,930	72,226	55,057	24,449	16,654	- 76.9	- 31
Total units.....	100,086	116,364	92,706	49,187	48,557	- 58.3	-

* Los Angeles, Orange, Riverside, San Bernardino and Ventura counties.

† Structures for which construction contracts were awarded but for which buildings were not required or issued. Included are public schools and college buildings, State and Federal structures, military and naval buildings, etc.

‡ Non-building construction: highways, freeways, bridges, dams, sewers, pipelines, flood control projects, waterworks, wharves, etc.

Source:

Conrad C. Jamison, Vice President and Economist, Research Department, Security Pacific National Bank.

January 23, 1976

inch in longest dimension, but larger than a 200-mesh screen; and "silt" or "clay" is the term for material smaller than 200 mesh.

The four main uses for aggregates in California and in the greater Los Angeles study area are:

Type of Aggregate	Plant site list price \$/ton (approximate rounded average— without tax or discount)
Portland cement concrete aggregate	\$2.50
Asphaltic concrete aggregate	\$2.50
Base and sub-base aggregate	\$2.25
Fill	\$1.50

Portland cement concrete aggregate is used in construction of homes and apartments, commercial and public buildings, and in engineering construction, such as dams, sewers, and docks. The other aggregates are used mainly for highway and road construction and repair.

To make Portland cement concrete, properly sized aggregate is mixed with powdered Portland cement and water, then mixed into a slurry which is poured into forms to harden. A chemical action between the cement and water results in the crystallization of hydrous calcium aluminum silicates, which harden and set, binding the

aggregate mass together into concrete. Naturally round particles in the aggregate are desirable as they improve the workability of the concrete as it is poured. If broken particles are present, and angular or flattish fragments exceed 15 percent of the total volume, workability can be maintained only by increasing the amount of sand and water, which can reduce strength, or by adding more cement which will increase the cost of the concrete.

Artificially sized and broken aggregates, commonly "crushed rock," are used to make asphaltic concrete and bases. Broken surfaces adhere to the hot-asphaltic mix better than rounded surfaces, and also provide interlocking surfaces which tend to strengthen the asphaltic concrete. Furthermore, broken particles tend to pack better and move less than rounded particles after the asphalt cools and hardens. Therefore, crushed rock makes better base courses and asphaltic concrete for highway and road construction, because it resists the tendency to flow when placed under great weight or long periods of applied stresses.

The specifications for fill materials are far less stringent than for aggregate. Under strict definition, most fill materials are not really aggregate, but for convenience, fill materials derived from sand and gravel deposits are included in this study.

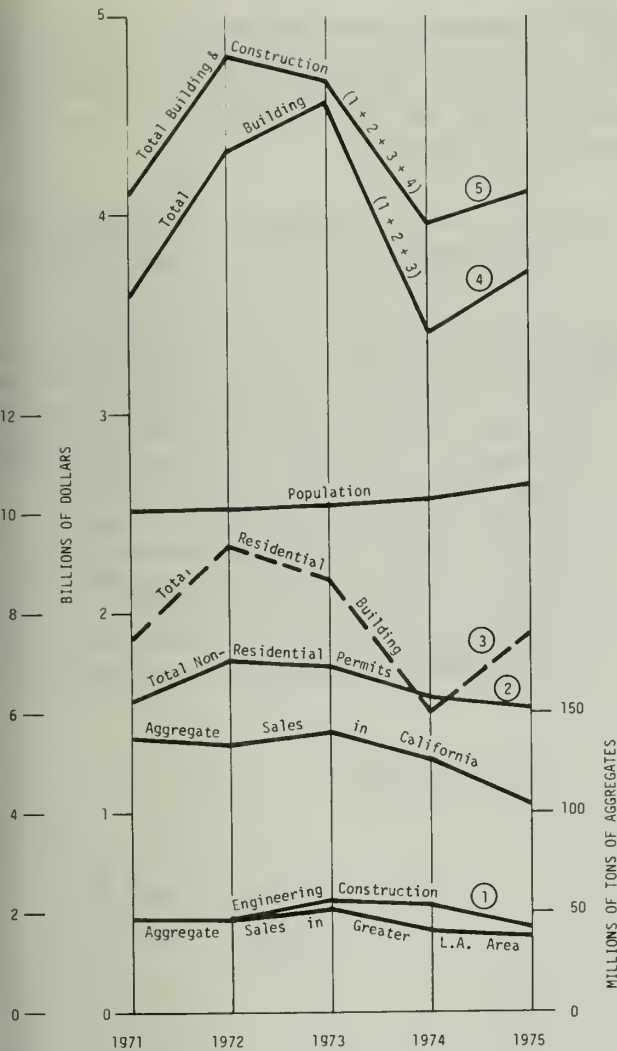


Figure 3. Comparison of aggregate sales, population growth, and value of building and construction in the greater Los Angeles area from 1971 to 1975.

Marketing and Transportation of Aggregate

The price of aggregate stockpiled at the plant site is lower than the delivered price to consumers, mainly because of transportation costs. With the relatively low price per ton of aggregate material, the producing industry just aims to keep the costs of mining and processing of aggregate low. Rarely is bank-run raw material, even from the highest grade deposits, physically or chemically treated for every type of aggregate. Therefore, every potential deposit must be tested to determine how large a percentage of its various components can meet specifications for the particular types of aggregate needed, what processing is required, waste ratios, etc.

Since the cost of transportation is critical, and competition in the industry is intense, deposits being considered for sources of aggregate should be located as

close as possible to the metropolitan areas that are to be the markets for the processed aggregate. A company must make environmental and surface reclamation and land use studies in order to obtain permits from governmental agencies before extraction begins. As a consequence, the development of a large new aggregate operation is a costly business, that can mount into millions of dollars. Sufficient capital is needed to accomplish all of the above as well as purchasing land and building plant facilities large enough to enable production at an economical cost per ton. Finally, financing must be sufficient to provide a proper labor force for operating the plant, and for a truck fleet, if one is held by the company. Sufficient reserves and resources of raw material must be available to sustain the life of the plant to amortize the total investment capital required.

Aggregates are commonly stored at the plant site and moved to delivery points on call, because of their volume, and seasonal variations in market demand. Large loads of aggregates minimize the transportation cost per ton mile, when they are delivered to the job site by truck and trailer combinations that carry a maximum load of about 25 tons.

Many aggregate producers in the greater Los Angeles area have their own truck fleets and transport their own products. A significant and increasing amount of aggregates are being hauled by independent truckers, because of the high cost of maintaining a truck fleet when the market demand is down as it has been in 1975 and 1976.

A large number of aggregate trucks on the freeways can contribute to environmental and traffic problems. The aggregate producers have made detailed analyses of the traffic problems, and have attempted to route trucks at appropriate times of day to avoid commuter traffic rushes. However, there is little question that as close-by deposits of material are depleted, longer hauls of aggregate will be required, and freeway traffic will be aggravated accordingly.

Minimum transportation rates for hauling aggregates and asphaltic concrete are fixed by the State Public Utilities Commission (PUC). Two main minimum rate tariffs (MRT) apply to haulage in the study area. MRT 17A applies to round-trip transportation between specified producing areas and points of delivery. This rate is based on 25-ton truck and trailer loads from production area to delivery point, and return. Areas and points are thoroughly described, and maps are available which outline the areas involved and give the appropriate code number for using the PUC rate manuals. Alternatively, MRT 7A is also for aggregates and asphaltic concrete, but it is based on cents per ton mile for a one-way haul for 25-ton truck and trailer loads. This schedule is used for transportation between areas and points that have not been specified by the PUC. It should be emphasized that MRT 17A and 7A represent minimum haulage rates, and

that a higher rate can be, and often is, charged. "Mixer" trucks (most of which have 9 yard capacity) which haul wet concrete from batch plants to delivery points are not covered by PUC rates. Cost of transportation for these trucks is about \$30.00/hour. It takes a truck about 5 minutes to load up at the concrete batch plant, and about 5 minutes per yard of concrete to unload at the delivery point, using about 50 minutes of time to deliver a full load, exclusive of highway time.

Because numerous deposits of raw aggregate materials now exist at convenient localities throughout the greater Los Angeles area, transportation costs are comparatively low. As low as these costs are, they still represent a major part of the total price for delivered aggregates, and for the final products made with aggregates. Figure 4 shows the PUC-approved transportation rates in the greater Los Angeles area as of October 2, 1976. Even with the limited data shown, it is clear that minimum transportation rates increase markedly if aggregate is brought in from other than local deposits. For example, the minimum rate from Irwindale to Los Angeles Civic Center is \$1.64 per ton, whereas from San Bernardino to the Civic Center the rate

is \$3.86—more than double, and more than the \$1.50 cost of the aggregate at the plant site. From Littlerock to the Civic Center, the minimum rate is \$4.46—almost triple the \$1.64 rate, and about double the \$1.50 cost of the aggregate at the plant.

Significance of the Aggregate Industry to the Economy of the Greater Los Angeles Area

Employment in the greater Los Angeles area for all phases of the aggregates industry (including quarrying, plant processing, delivery, and ready mix operations) accounts for about 3,000 jobs. In 1975, the total civilian employment in the greater Los Angeles area was about 10 million, according to Chamber of Commerce estimates. Thus, the aggregate industries employ less than 0.1 percent of the total civilian employment. Within the next 10 years, if present economic trends continue, there may be a slight drop of employment in the aggregate industry. New large automated plants, such as Conrock's Reliance plant near Irwindale, require fewer employees to produce a ton of aggregate than older plants, resulting in a cost

COST FIGURES BASED ON PUBLIC UTILITY COMMISSION (PUC) RATES (10/2/76). MINIMUM RATE TARIFF 7A (CENTS PER TON MILE) RATES ARE HIGHER THAN FOR MINIMUM RATE TARIFF 17A. TARIFF 17A* IS BASED ON 25-TON TRUCK AND TRAILER LOAD LOTS FROM A SPECIFIED PRODUCTION AREA TO A SPECIFIED DELIVERY AREA AND RETURN. TARIFF RATE 7A IS BASED ON A 1-WAY 25 TON LOT HAUL.			PRODUCTION AREAS																				
			LITTLEROCK -	SOLEDAO (19LL)**	SANTA PAULA (561)	SANTA SUSANA (56P)	VENTURA (56J)	SATICOY (56C)	SUN VALLEY (19A)	IRWINDALE (19G)	UPLAND -	FONTANA -	SAN BERNARDINO -	REOLANDS (36M)	COLTON -	CORONA (33R)	GYPSUM CANYON -	ORANGE (30A)	IRVINE LAKE (30Q)	GLEN IVY (33S)	TRABUCO CREEK (30B)	SAN JUAN CREEK (30P)	
DELIVERY AREAS	PALMOALE	19847	1	1.33	1.87	4.29	3.46	5.09	4.64	3.30	4.64	5.37	6.21	6.62	7.16	6.62	6.62	6.21	5.93	6.21	6.62	6.62	7.16
	SAUGUS	19700	2	2.30	*.99	2.19	2.08	3.13	2*.96	1*.06	2*.93	4.11	4.81	5.37	3*.96	5.09	5.09	4.81	3*.60	4.64	5.37	5.09	5.65
	GRANAHA HILLS	19015	3	2.77	1*.45	2.64	1*.55	3.30	2*.72	1*.09	2*.97	3.42	4.11	4.29	3*.99	4.64	4.46	4.46	3*.64	4.11	5.09	4.64	5.09
	VAN NUYS	19072	4	3.13	1*.80	3.30	1.54	3.51	2*.99	1*.04	2*.59	3.13	3.97	4.64	3*.61	4.29	3.97	4.64	3*.26	3.86	4.46	4.11	4.64
	WOODLAND HILLS	19084	5	3.74	2*.19	2.71	1*.82	2.89	2*.48	1*.57	2*.99	3.51	4.29	4.81	4*.01	4.64	4.64	4.46	3*.66	4.29	5.09	4.64	5.37
	LOS ANGELES CIVIC CNTR.	19174	6	4.46	2*.58	3.86	2.52	4.29	3*.77	1*.45	1*.64	2.36	3.13	3.86	2*.66	3.36	3.07	3.07	2*.31	2*.80	3.51	3*.17	3.97
	INTERST. SANTA MONICA 10 & SAN DIEGO FREEWAYS 40S	19184	7	3.86	2*.33	3.63	2*.63	3.86	3*.36	1*.72	2*.15	3.01	3.86	4.11	3*.17	3.97	3.74	3.63	2*.84	3*.29	4.11	3*.66	4.46
	RIVERSIDE	33015	8	4.46	5.37	6.62	5.09	7.16	6.62	4.11	2.41	1.66	1.54	1.42	1*.81	.97	1*.19	1.66	2*.20	2.58	1*.60	3.51	4.11
	SANTA FE SPRINGS	19438	9	4.81	3*.32	4.64	3.42	5.93	4*.58	2*.20	1*.42	2.25	3.51	3.51	2*.44	3.13	2*.32	1.85	1*.56	2.08	2*.64	2*.43	3.63
	BREA	30003	10	5.65	5.65	5.65	4.11	5.93	5.37	3.01	1*.70	1.72	3.01	2.77	1*.95	2.58	1*.76	1.17	1*.25	1*.74	2*.08	2*.31	2.59
	LONG BEACH	19466	11	5.37	3*.71	5.09	3.97	5.65	4*.73	2*.63	2*.36	3.01	4.29	4.11	3*.38	4.11	2*.85	2.47	1*.80	2*.29	3*.17	2*.66	3.42
	SANTA ANA	30046	12	5.65	5.93	5.65	4.29	5.93	5.37	3.07	2*.06	2.36	3.30	3.01	2*.36	3.07	1*.81	1.30	*.76	1*.25	2*.13	1*.59	1.87
	HUNTINGTON BEACH	30077	13	5.09	5.93	5.93	4.64	6.62	5.37	3.30	2*.18	3.42	4.11	3.86	3*.05	3.74	2*.42	2.03	1*.37	1*.86	2*.74	2*.06	2.30
	SAN JUAN CAPISTRANO	30101	14	6.21	7.16	6.62	6.56	7.16	6.62	4.29	2*.99	3.63	4.46	4.11	3*.32	4.11	2*.69	2.58	1*.64	1*.60	3*.01	*.59	.75
	VENTURA	56056	15	5.09	5.65	1*.16	2*.63	*.61	1*.06	3*.88	5*.30	5.93	6.62	7.16	7.69	7.16	6.62	6.62	5.93	5.93	7.16	6.62	7.16
	SANTA PAULA	56041	16	4.29	3*.04	*.65	2*.25	1*.31	*.91	3*.08	4*.96	5.37	6.21	6.62	7.16	6.62	6.62	6.62	5.93	5.93	7.16	6.62	7.16
	UPLAND	36046	17	5.37	6.21	5.93	4.46	6.21	5.37	3.13	1*.62	X	1.54	2.47	*.66	1.72	1*.67	1.66	1*.77	2.58	1*.99	3.42	3.97
	SAN BERNARDINO	36037	18	6.62	5.09	7.16	5.65	7.16	6.62	4.46	2*.72	1.85	.84	X	1*.83	.84	1.72	2.36	2*.61	3.30	2.41	4.11	4.64
	CORONA	33048	19	6.62	6.62	6.21	5.09	7.16	5.93	3.97	2*.27	2.25	2.08	1.85	1*.68	1.78	1*.75	.84	1*.50	1.97	1*.01	2.89	3.42

*17A IS USED FOR RATE DETERMINATION.

** (19LL) NUMBER AND LETTER ENCLOSED IN BRACKET REFERS TO PUC AGGREGATE LOADING ZONE.

Figure 4 Transportation cost (dollars per ton) to truck aggregates between selected production areas and delivery areas, greater Los Angeles area in late 1976.

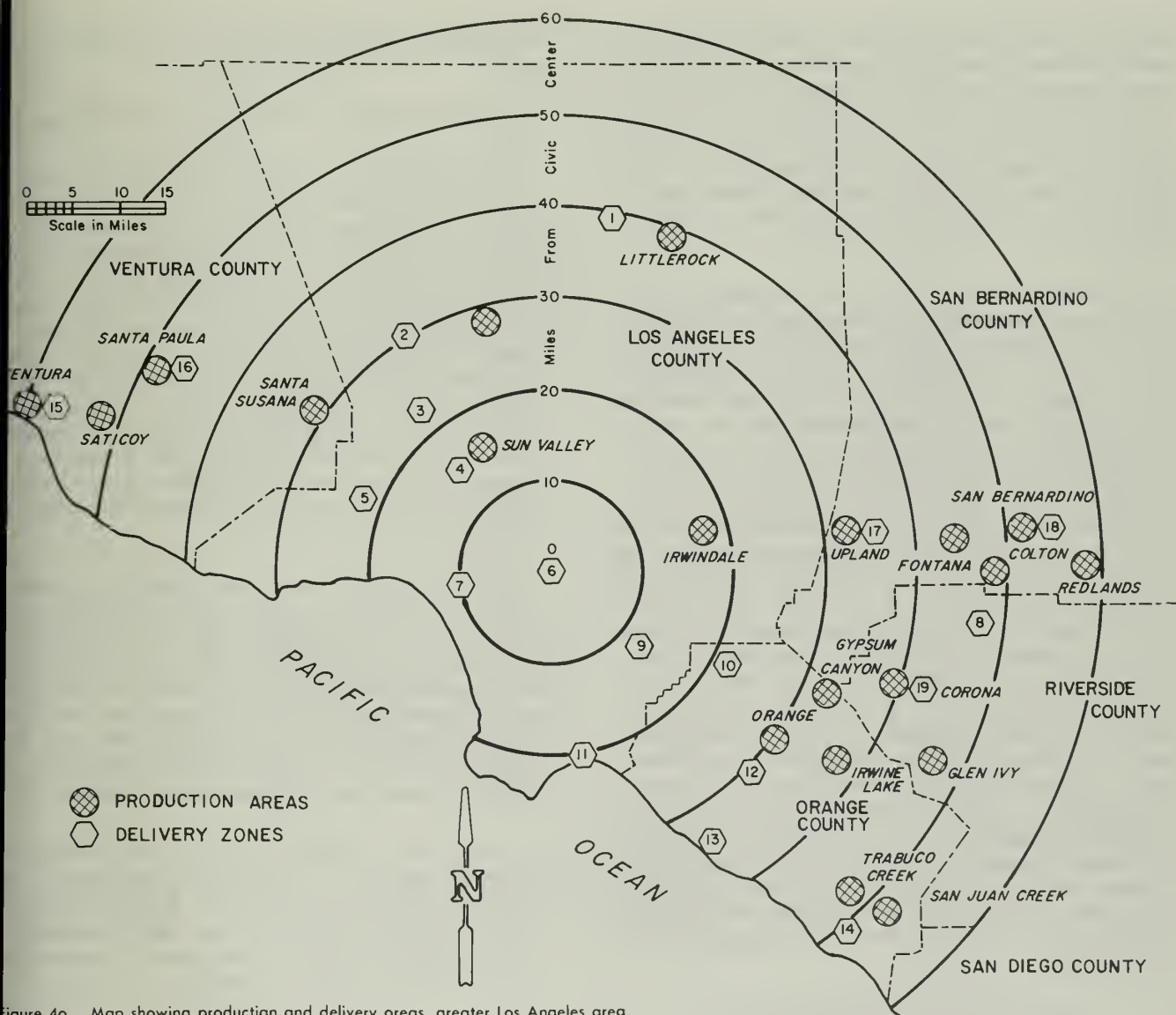


Figure 4a. Map showing production and delivery areas, greater Los Angeles area.

avings. The general trend is toward larger plants and deposits, more efficiency, and minimizing the costs to deliver a ton of aggregate.

Although the number of employees in the aggregates industry is small compared to some industries, it is significant, because aggregates and the products made from aggregates are an essential part of the construction industry, and the rest of the construction industry depends on aggregate production as its starting point. Many trades are affected by the cost and availability of aggregates. Contractors, cement manufacturers, asphalt producers, carpenters, electricians, truck drivers, mechanics, and many other trades people depend to some degree on the availability of aggregates for freeway and road building, and on concrete for foundations and structures, both public and private. Anything that affects costs of the aggregate industry has a direct impact on these

interrelated industries. In other words, the activity and efficiency of the relatively few in the aggregate industry work force have a disproportionately strong influence on the general economy.

Royalty payment by aggregate producers to landowners, total taxes paid, total payrolls, and total capital investments of the aggregate industry in 1975 were not determined in this study. However, it is estimated based on questionnaires that royalty payments were roughly \$6 million in the study area, total taxes were roughly \$10–12 million, total annual payrolls possibly \$30 million, and capital investments at least \$150,000,000.

In 1975, the total value of building and construction within the area of this study was \$4,104,162,000 (table 2). Estimating the average value of all aggregates produced in

the study area at about \$2.50 per ton in the stockpile at plants, and production in 1975 at about 38 million tons, the total value of the produced aggregates was \$95 million, or about 2.3 percent of the total value of building and construction. However, the significance and value of aggregates as basic construction materials have multiplier effects, and their influence on construction costs cannot be figured solely on value or price of aggregates per ton at the plant site.

To illustrate this situation, two examples involving concrete and asphaltic concrete were prepared (figure 5). These two materials represent the major use of aggregates in the greater Los Angeles area. Volume of material used for the concrete analysis is expressed in (cubic) yards, the way it is sold. A ten-mile haul after batching was used for each analysis, as an average distance from a batch plant to a delivery point. Most of the 144 Portland cement and asphaltic cement batch plants throughout the area (appendix 1) are not at aggregate deposit sites, but are closer to the main delivery areas, in order to keep the cost of transportation down. Of the \$25 per yard delivered price for concrete, only \$2 is the cost for raw aggregate; the remainder is for transportation, cement, processing, and profit margin. Even though the price of aggregates is comparatively low, about 87 percent by weight of Portland cement concrete is aggregate, and about 95 percent by weight of asphaltic concrete is aggregate. A raise in the price of aggregate does not affect the delivered price of concrete as much as do increases in the cost of transportation, binder materials, or processing. The availability of aggregates and their nearness to the market are critical factors in the health of the construction industry, and any significant change in either can seriously affect costs to the construction industry and the public, particularly for the massive tonnages used in public works construction.

PREPARATION OF REPORTS ON AGGREGATE OPERATIONS

To gather the extensive data required in this study, and to be sure the data was complete and accurate for each aggregate operation covered, a standard interview technique, data recording and workup format were rigorously followed. (See "Hypothetical Sample Summary Work Sheet," figure 6; "Guideline for Examination of Aggregate Operations," appendix II; and "Mineral Property and/or Mill Processing Plant Report," appendix III.)

Initial preparations for the study included meetings with the aggregate industry to explain the study and obtain cooperation. All available statistics and descriptions of each operation were collected, along with copies of operating permits, waste water discharge requirements, and economic and planning information. A master address list was assembled, and all aggregate deposits, processing plants, and Portland cement concrete

and asphaltic concrete batch plants were plotted on maps.

Reserve-Resource Criteria and Terminology

Two aspects of the "Guideline for Examination of Aggregate Operations" (appendix II) deserve further explanation. First, Part IV of Section G, "Quality control for processed material" is significant because materials for aggregates, except for lower grades of fill, must meet certain strength, sizing, and compositional specifications. Not all alluvial raw material qualifies for use as aggregates, so potential deposits must be carefully tested before decisions are made to quarry and process them. Sampling a potential aggregate deposit for testing can be a major task involving drill holes, test pits, and trenches. As much as 25 tons may be required for one sample. It is necessary to run these large samples through an aggregate processing plant in order to determine suitability for aggregates.

Table 3 contains brief descriptions of common aggregate tests. These tests are described in the Materials Manuals Vols. 1-3, published in 1971 by the California Department of Transportation, Division of Highway Engineering. These complex specifications were based on testing for Portland cement, asphaltic concrete aggregates and base materials. They partially appear in the Appendix IV, and fully appear in the "Standard Specifications" published by the California Department of Transportation, January 1972.

Secondly, Part V of the "Guideline for Examination of Aggregate Operations," "Reserves and Resources," and their calculations, are significant because a precise understanding of the terms "reserves" and "resources" as they are applied throughout this report, is essential for understanding the section on Supply.

The following definitions have been adopted by the California Division of Mines and Geology, and apply to aggregate deposits as well as to all other mineral deposits.

Mineral Reserves: Measurable amounts of mineral-bearing materials that can be produced with current technology under existing economic and political conditions.

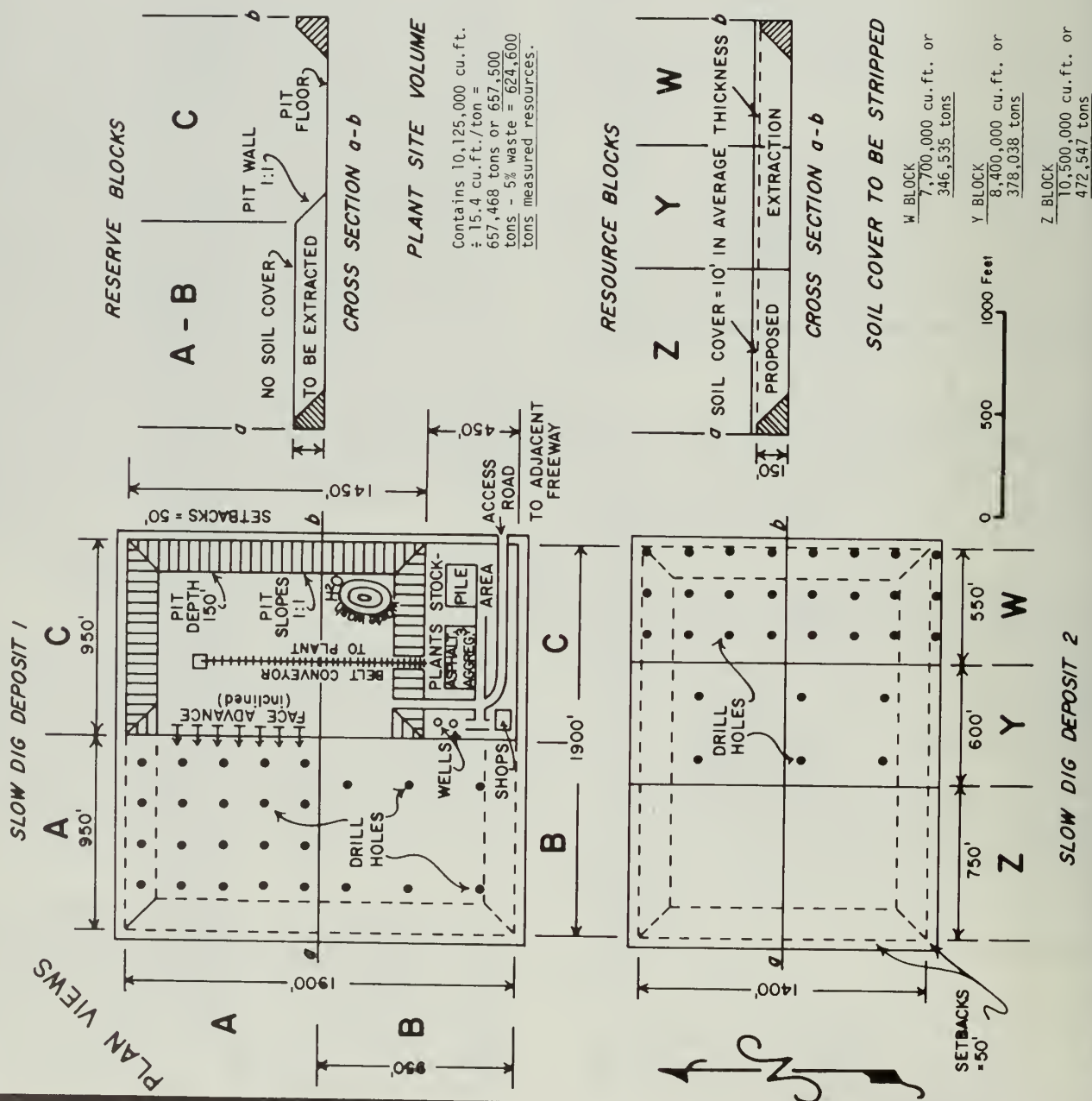
Mineral Resources: Mineral-bearing materials that could become mineral reserves either through future technological developments, improved economic conditions, different political conditions, or a combination of all these.

For purposes of this report, the following more specific definitions are used:

- **Aggregate reserves** are those deposits of aggregate raw materials that: (1) are under current company ownership or lease; (2) are possible to extract economically using current technology; and

PRODUCT	"VALUE" OF ALLUVIAL MATERIAL IN THE GROUND	COST OF AGGREGATES IN STOCKPILE	COST OF TRANSPORTATION TO CONCRETE BATCH PLANT	COST OF CONCRETE BATCHING	PROFIT MARGIN	COST OF TRANSPORTATION TO CONSUMER AT DELIVERY POINT	"VALUE" TO CONSUMER AT DELIVERY POINT
Concrete Made from aggregates and Portland cement 1 Yard NOTE: 1 yard of concrete weighs about 2 tons. Portland Cement 470 lbs. Wet Gravel 1,766 lbs. Wet Sand 1,615 lbs. 6% Water 180 lbs. TOTAL 4,031 lbs.	Land purchase or lease, exploration, environmental costs, etc.: about \$0.25/ton or because there are ± 1.6 tons $(0.9 + 1/4)$ size, and $0.7 - 1/4$ size) of aggregates in 1 yard of concrete: about \$0.40/yard	After washing, sizing, and transfer to stockpile: about \$1.25/ton or about \$2.00/yard	15 mile haul to plant from deposit in 25-ton truck lots using PUC minimum rate tariff 7A is: \$1.35/ton or \$2.15/yard	Bulk Portland cement is about \$2.50/100 pds; 470 lbs. are needed for 1 yard of concrete: \$11.75/yard + capitol, marketing, sales, overhead, labor and tax costs: about \$2.00/yard $\$11.75 + \$2.00 = \$13.75/\text{yard}$	About 4-1/2% of delivered price or about \$1.15/yard	Carried in 9-yard capacity "mixer" trucks; \$30.00/hour cost of transportation: 5 minutes to load truck at batch plant, about 50 to haul concrete 10 miles to delivery point, and 5 minutes per yard, or 45 minutes to unload truck; about 1 hour and 40 minutes total time: about \$50.00 or \$5.55/yard	About \$25.00 per yard of concrete or \$225.00 per "mixer" truck load
TOTALS	\$0.40	\$2.40	\$4.55	\$18.30	\$19.45	\$25.00	
PRODUCT	"VALUE" OF ALLUVIAL MATERIAL IN THE GROUND	COST OF AGGREGATES IN STOCKPILE	COST OF TRANSPORTATION TO ASPHALTIC BATCH PLANT	COST OF ASPHALT BATCHING	PROFIT MARGIN	COST OF TRANSPORTATION TO CONSUMER AT DELIVERY POINT	"VALUE" TO CONSUMER AT DELIVERY POINT
Asphaltic Concrete Made from aggregates and oil 1 Ton NOTE: 1 ton of asphaltic concrete contains about 5% by weight of oil and 95% by weight of coarse and fine aggregates	Land purchase or lease, exploration costs, environmental analyses costs, etc.: about \$0.25/ton or 0.95×0.25 or about \$0.24	After crushing, washing, sizing, and transfer to stockpile: about \$1.25/ton or 0.95×1.25 or about \$1.19	15 mile haul to plant from deposit in 25-ton truck lots using PUC minimum rate tariff 7A is: \$1.35/ton or 0.95×1.35 or about \$1.28	Oil is about \$64.00/ton 5% by weight is used in mix: about \$3.20 + capitol, marketing, sales, overhead, labor and tax costs: about \$2.50/ton $\$3.20 + \$2.50 = \$5.70/\text{ton}$	About 7% of delivered price or about \$0.75/ton	10-mile haul from batch plant to delivery point in 25-ton hot mix truck lots using PUC minimum rate tariff 7A is: \$1.21/ton	About \$10.37 per ton of asphaltic concrete or \$259.25 per truck load
TOTALS	\$0.24	\$1.43	\$2.71	\$8.41	\$9.16	\$10.37	

Figure 5. "Value" or cost of 1 yard of concrete and 1 ton of asphaltic concrete delivered to a consumer at a delivery point 10 miles from a concrete or asphaltic concrete batch plant in late 1976. These examples were developed from data gathered throughout the greater Los Angeles study area and do not apply to any individual company operation. It is assumed, however, that the batch plants belong to the company that owns the aggregate deposits. The delivered price is realistic, but will vary somewhat in different localities. Data given here show that both the manufactured products require a large amount of aggregates, but that other additive materials such as Portland cement and oil, and transportation cost much more than the aggregates in a stockpile. Profit margins for both products, particularly for concrete, indicate that the sellers must depend largely on volume business for overall profit.



A BLOCK
 $\frac{115,687,500 \text{ cu. ft.} \div 15.4 \text{ cu. ft./ton} = 7,512,175 \text{ tons} - 5\% \text{ waste} = 7,136,567 \text{ tons or } 7,137,000 \text{ tons of measured reserves.}}$

B BLOCK
 Same size as A Block, therefore contains 7,137,000 tons x 0.8 = 5,710,000 tons of indicated reserves.

C BLOCK
 Raw material in this block has been excavated. It amounted to about 172,313,000 cu. ft. ÷ 15.4 = 11,189,123 tons or 11,189,000 tons - 5% waste = 10,630,000 tons.

Average yearly sales from the plant has been about 1,300,000 tons and it has been in operation about six years.

W BLOCK
 $\frac{90,750,000 \text{ cu. ft.} \div 15.4 \text{ cu. ft./ton} = 5,896,686 \text{ tons} - 5\% \text{ waste} = 5,601,852 \text{ tons or } 5,602,000 \text{ tons of measured resources.}}$

Y BLOCK
 $\frac{112,500,000 \text{ cu. ft.} \div 15.4 \text{ cu. ft./ton} = 7,305,195 \text{ tons} - 5\% \text{ waste} = 6,939,935 \text{ tons or } 6,940,000 \text{ tons} \times 0.8 = 5,552,000 \text{ tons of indicated resources.}}$

Z BLOCK
 $\frac{115,875,000 \text{ cu. ft.} \div 15.4 \text{ cu. ft./ton} = 7,524,350 \text{ tons} - 5\% \text{ waste} = 7,148,132 \text{ tons or } 7,148,000 \text{ tons} \times 0.6 = 4,289,000 \text{ tons of inferred resources.}}$

COMPANY OPERATION	1975 PRODUCTION (TONS)	AVERAGE YEARLY PRODUCTION OVER PAST 5 YRS (TONS)		AGGREGATE USES CONCRETE ASPHALTIC		1976 PRICES F.O.B.	DEPOSIT TYPE AND AGE	FRACTION (% > 0.075")	WASTE FACTOR (BY WEIGHT)	COMMENTS
		CONCRETE	ASPHALTIC	CONCRETE	CONCRETE					
Go-Rapid Aggregate Company/Slow-Dig deposits 1, and 2 City of Irwindale	1,000,000	1,300,000	050%	25%	025%	Concrete aggregates \$2.50/ton Asphaltic concrete aggregates \$2.40/ton Bases \$2.30/ton	Flood plain - San Gabriel River sand and gravel; Holocene	In place 75% Produced 60%	5% - Clay size frac- tion.	Both deposits on fee land, Zone Q, use permit and environmental controls from City of Irwindale; waste water discharge requirements current, water from wells, waste wash water to pit for infiltration, mean ground water level 200' below surface; contract trucking; asphaltic concrete plant owned by company - 200 tons per day rated capacity - aggregate of excellent quality.

MINING AND AGGREGATE PLANT OPERATION	RESERVES (TONS)	RESOURCES (TONS)	MATERIAL AND TONNAGE FACTORS	DEPOSIT LIFE
Dragline scraper and loaders to grizzly and primary jaw crusher to conveyor belt - in pit/material to standard crushing and sizing plant, 1800 ton/hour rated capacity; daylight hours for operation, five days a week, plant about six years old.	Measured --- 7,137,000	Measured --- 5,602,000	Coarse and fine material composed mostly of granitic and metamorphic rocks and quartz; particles hard, durable, well rounded, generally spherical. 130 lbs./cu.ft. or 0.065 tons/ cu.ft. or 15.4 cu.ft./ton Soil Cover 90 lbs./cu.ft. or 0.045 tons/ cu.ft. or 22.2 cu.ft./ton	12,847,000 tons of reserves ÷ 1,300,000 tons of average yearly production = 9.9 or about ten years of life. Indicated reserves may prove to be greater than adjusted value. Also if plant can be moved and additional 624,600 tons can be moved in reserves. Also, if resources can be moved into reserves it would add at least 15,443,000 tons or at least 12 more years of life.
	Indicated -- 5,710,000	Indicated -- 5,552,000		
	(adjusted)*	(adjusted)*		
	Total -- 12,847,000	Inferred --- 4,289,000		
		(adjusted)		
		Total -- 15,443,000		
	</			

RECLAMATION

After extraction of the north
1/2 of C Block, and all of A
Block, Class II waste (garbage)
will be accepted for filling the
north part of the pit. Eventually
the entire pit will become a
sanitary landfill, as approved by
the City of Irwindale.

If Deposit 2 is extracted, the
pit may also become a sanitary
landfill. To date, approval has
not been obtained from the City,
nor has a use permit been
granted for extraction.

*Adjusted by multiplier factor for
"current value". See Reserve and
Resource Calculation Factors section.

SAN GABRIEL RIVER FAN PRODUCTION AREA, LOS ANGELES COUNTY

Figure 6. Example of a summary worksheet for the hypothetical "Go-Rapid Aggregate Company's" operation in the City of Irwindale, Los Angeles County. The data are conceptual but realistic, and do not apply to any actual aggregate operation. Sketch diagrams and notes of this type were prepared for each aggregate deposit examined in the study area.

In this example, "Slow Dig deposit 1" is being mined, and the use permit is being held by the company for the entire extraction area. This permit specifies that the pit can be no deeper than 150 feet, and pit walls must be sloped to 1:1 slopes (45°). The example shows "Slow Dig deposit 2" as being nearby and owned by the company, but without a use permit for extraction. For purposes of resource calculations, the same pit depth and angle were assumed for its pit walls. Development drilling has been done on Slow Dig deposit 1, but only in Block W of Slow Dig deposit 2. Exploratory drilling has been done on Block Y of deposit 2, but no exploration work has been done on Block Z. The tonnage was determined by measuring the weight of 1 cubic yard of material excavated from the pit slope in 3 different locations. The waste factor was determined through experience of the company over the operating life of the plant. Deposit 1 has no overburden, but an estimated 10' of soil cover on deposit 2 would have to be stripped prior to excavation of aggregates.

All these factors are typical of conditions found at actual aggregate operations examined in this study.

TABLE 3. Common aggregate tests with brief descriptions (From California Department of Transportation, Division of Highways, Materials Manual, 1971).

TEST SUBJECT	TEST METHOD NO.	BRIEF DESCRIPTION
Abrasion of coarse aggregate by use of the Los Angeles Rattler Machine	211-D	Used to determine strength and resistance to wear of coarse aggregate to be used in concrete to impact in a rotating cylinder containing steel spheres at 100 or 500 revolutions.
Determination of bulk specific gravity and absorption of coarse and fine aggregates	206-D (coarse)	Sample is soaked in water, weighed in the water and in air, and again after it has been oven dried. The weights are used to determine the bulk specific gravity (ratio of weight of given volume of aggregates to weight of equal volume of water). Material in most aggregates must have a value of 2.5 or greater. Absorption is given as a percent ratio of the weight of water absorbed to the dry weight of sample. Material with high absorption can cause a deleterious bond with cement paste and aggregate particles.
	207-D (fine)	
Aggregate sample preparation	201-D	Description of processes used for preparing untreated material as received from the field, for required tests. Separation by screening, weighing, removing soil coatings from coarse aggregates, breaking up clods, and splitting out representative test samples of specified size are some of the more important techniques used in sample preparation.
Cleanness of coarse aggregates	227-E	Used to determine the amount, fineness, and character of claylike materials present in processed, but unwashed coarse aggregates, or screenings in the form of coatings or otherwise by washing sample and measuring the amount of settled fines. Values are expressed as percentages. Material must have clean surfaces to insure a quality bond with cement in concrete.
Sieve analysis of fine and coarse aggregates (size grading)	202-G	Used to determine the particle size and particle size distribution of a sample by use of sieves. Sample is weighed and passed through a group of interlocking sieves of progressively finer mesh openings which are vibrated in a mechanical shaker. The particles on each sieve are weighed and related to the weight of the whole sample as a percentage; data is plotted on appropriate graphs. Size grading affects flowability, residual void spaces and strength of concrete and asphaltic concrete.
Determination of relative resistance of aggregate to produce detrimental clay-like fines (durability)	229-E	Aggregate sample is cleaned, dried, weighed, graded by size particles into 2 fractions (+4 mesh, and -4 mesh), placed in washing vessels and agitated in water for about 10 minutes. Sample is then washed to remove fines. The amount of fines in suspension are compared to the amount of coarse particles and a durability index is obtained. If the aggregate produces too many fines it can cause bonding problems.
Freeze-thaw resistance of aggregate in air-entrained concrete	528-B	Used to determine resistance to deterioration of aggregates in air-entrained concrete when subjected to a specified period of soaking in water with intervening cycles of freezing and thawing.
Petrographic examination	215-B	Sample is examined by hand lens and microscope to determine grain shapes, sizes, and roundness, grain colors, surface condition of grains, and any other significant properties and conditions such as the presence of minerals or coating of minerals that may cause alkali reactions (see A.S.T.M. C-289-71). Deleterious material can effect strength, hardness, color, and permanence of concrete and asphaltic concrete.
Relative compaction of treated aggregates	216-C	Used to determine the ratio of in-place wet density of aggregate to the test maximum wet density of the aggregate when compacted in a split cylindrical mold. Amount of compaction is important for determining stability of bases.
Sand equivalent	217-I	Rapid field test to determine the relative proportions of detrimental fines or clay-like material in fine aggregates. Sample is shaken in a graduated glass cylinder in water containing calcium chloride, glycerine, and formaldehyde. After settling the relative volume of clay and sand is measured. Ratio of sand to clay is given as a whole number; higher numbers indicate lower clay contents. Too many fines can have a negative effect on the permanence of concrete and asphaltic concrete.
Soundness	214-E	Used to determine resistance (% weight loss) of aggregate sample to disintegration in a saturated solution of sodium sulfate. Force of crystallization of sodium sulfate salts absorbed from solutions can cause disintegration, cracking, or flaking. Sample is dried, weighed, and sieved prior to, and after soaking. Particles larger than 3/4-inch are examined by eye or with a hand lens. Unsound material affects strength, and susceptibility to damage from expansion of absorbed water on freezing.
Potential alkali reactivity of cement-aggregate combinations	A.S.T.M. C-289-71	Aggregates may contain opaline silica or other minerals that will react chemically with sodium and potassium in some types of Portland cements to form alkali silica gels which hydrate, swell and cause expansion, cracking and deterioration of concrete. Reactivity is determined by noting the amount of reaction during a 24-hour period at 80 C between a 1 N sodium hydroxide solution and aggregate that has been crushed and sieved to pass a No. 50 sieve and be retained on a No. 100 sieve. Reactivity can also be determined by measuring expansion of mortar bars made from Portland cement and the aggregate sample over a period of 1 or 2 years.

(3) have permits issued for their extraction, as of July 1976. The only factor distinguishing aggregate reserves from aggregate resources throughout this report is that reserves have permits for extraction, whereas resources lack permits. In computing both reserves and resources for each production area, the setbacks, pit slopes, and maximum pit depths that were (or would be) required by the appropriate governmental agencies as of July 1976 were used. Raw material underneath processing plants and other buildings were counted as resources.

Categories of reserves and resources are “measured,” “indicated,” and “inferred.”

• *Measured reserves or resources* are those for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, or drill holes, and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, and quality of mineral content are well established. The computed tonnage and grade of each deposit are judged to be accurate within stated percentage limits of 20%.

• *Indicated reserves or resources* are those for which tonnage and grade are computed with less certainty than for measured deposits. Computations are based partly on specific measurements, samples, or production data, and partly on projection for a reasonable distance using geologic evidence. The sites available for inspection, measurement, and sampling are too sparse or inappropriately spaced to outline the mineral bodies completely, or to establish the grade throughout the deposit.

• *Inferred reserves or resources* are those for which tonnage and grade are quantitatively estimated, based largely on broad knowledge of the geologic character of the deposit; few, if any, samples or measurements are available. The estimates are based on assumed continuity or repetition, for which there is geologic evidence, such as comparison with nearby or similar deposits. Bodies that are completely concealed may be inferred if there is specific geologic evidence of their presence. Estimates of inferred reserves or resources should include a statement of their boundaries.

Reserve and Resource Calculation Factors

All of the production areas established for this report had two or more categories of reserves or resources. The total reserve figure (measured, indicated, and inferred) for each producing area was used in projecting its remaining productive life.

The total resource data is also important and it was used to estimate possible additional productive life for the deposit, because the issuance of an appropriate permit would convert its resources into reserves.

Because the different categories of both reserves and resources reflect different degrees of certainty, it was necessary to develop a rationale to make them comparable when combined into total reserves and total resources. An arbitrary factor was devised, called “current value,” to be used as a multiplier. Accordingly, measured reserves or resources were given a current value of 1.0; indicated reserves or resources a current value of 0.80; and inferred data a current value of 0.60. Measured indicated and inferred tonnages of each category were multiplied by the appropriate current value whenever they were combined as total reserves or total resources. Figure 6 illustrates the method used to calculate the life of a deposit.

All tonnages in this report are in short tons, 2000 pounds. Tonnage factors (i.e. tons per cubic yard) were determined in several ways. The excavation and weighing of 1 measured cubic yard of floodplain or bedrock material from a pit slope in several locations provided the most accurate tonnage factor. Because stream channels are more difficult to sample than pits, an overall average figure was used for stream channel deposits, based upon operating experience over a number of years. In determining this number, 30 percent porosity was assumed. At some bedrock deposits the tonnage factor had to be approximated, based upon the rock types present, size of fragment, percentage of fine material and estimated porosity. Examples of tonnage factors used in this report are shown below.

	Pounds/ Cubic Foot	Tons/ Cubic Foot	Cubic Feet/ Ton
Stream channel	116	0.058	17.3
Alluvial fan (San Gabriel)	130	0.065	15.4
Bedrock (Gypsum Canyon)	150	0.075	13.3
Bedrock (Raund Canyon)	140	0.070	14.3
Dry sand	106	0.053	18.9
Dry gravel	97	0.048	20.7

SUPPLY

Aggregate Resource Availability—Development Factors in the Greater Los Angeles Area

Geologic occurrence of aggregate source deposits

The size, shape and composition of aggregate deposits in the study area vary considerably. This diversity results from a complex interplay of varying factors of source materials, weathering, transportation, and deposition of material, as discussed below.

Stream channel deposits of sand and gravel are the source of aggregate in several production districts, includ-

ing the Ventura and Santa Clara Rivers in Ventura County; Temescal Creek in Riverside County; Trabuco, Santiago, San Juan Creeks and the Santa Ana River in Orange County; the Santa Ana River in San Bernardino County; and the upper Santa Clara River in Los Angeles County. During periods of heavy rainfall and runoff, large quantities of material are moved as bedload in suspension along these channels. As the flow rate and energy in the streams decrease, some of this material settles to the bottom and forms deposits of sediment. Such deposits are desirable sources of aggregate because they are easily mined and they are periodically replenished by rainfall and runoff.

Floodplain deposits of sand and gravel form as a result of streams overflowing their channels during high water stage. As the overflowing water spreads onto the adjacent plain, the reduction in transporting power of the water causes deposition of its suspended load of sediments. The resulting deposits are characterized by their wide lateral extent and the presence of considerable sand, silt and clay. Floodplain deposits are mined adjacent to Santiago Creek in Orange County, the Santa Clara River in Ventura County, and the Santa Ana River in San Bernardino County. Floodplain deposits tend to be less desirable as a source of aggregate than other types of deposit because large proportions of finer size material must be removed from them to make high quality aggregate.

Alluvial fans commonly develop in valley areas near the bases of mountain fronts. Alluvial fans are characterized by sparse vegetation and infrequent torrential rainfall. Within the study area, alluvial fans are well developed at the bases of the San Gabriel and Santa Ana Mountains. These large fan-shaped masses of poorly sorted aggregate accumulate during periods of sudden heavy rainfall when streams have substantial transporting energy as they flow out of the highlands. Upon reaching the base of the mountains, the stream gradient flattens suddenly, causing a large drop in energy and a rapid deposition of materials, which gradually build up to form the alluvial fan. These features represent desirable sources of aggregate because they yield a variety of different sizes of materials which are generally very durable. At their upper ends, some alluvial fans have excessively large boulders and an overabundance of coarse material for ideal aggregate sizing.

Bedrock deposits that are quarried as sources of aggregate in this study area include older sedimentary formations and crystalline rocks. Both types can be sources of aggregate, provided they are amenable to surface mining methods without excessive blasting or disaggregating costs, and provided the rock is not extensively weathered.

In Los Angeles County four aggregate pits are in bedrock. Three of these are in Soledad Canyon within the upper Santa Clara production district, where gabbro from the Precambrian San Gabriel intrusive complex and conglomeratic nearshore marine sediments of the Miocene

Mint Canyon Formation are mined by P. W. Gillibrand Company and by Curtis Construction Company, respectively. The other bedrock deposit is on the northeast flank of the Palos Verdes Hills, where Chandler's Palos Verdes Sand and Gravel Company extracts aggregate from massive, slightly indurated beach sand deposits of the Pleistocene San Pedro Formation. P. W. Gillibrand Company, Somis Rock and Sand Company, S. P. Milling Company and Tapo Rock and Sand Company extract aggregate from bedrock deposits in the Simi Valley production district in Ventura County. In that area, aggregate is produced from conglomerate of the Pliocene Saugus Formation, marine sandstone and conglomerate of the Pliocene Pico Formation, sandstone and conglomerate of the Pleistocene San Pedro Formation, and conglomerate of the Paleocene-Eocene Santa Susana Formation.

In Orange County, several bedrock formations are being mined for aggregate. El Toro Materials processes aggregate from sandstone of the Oso member of the Pliocene Capistrano Formation, and Blue Diamond Materials processes sand and gravel from conglomerate of the Miocene Puente Formation. Blue Diamond Materials also produces aggregate from conglomerate of the Pleistocene San Pedro Formation a few miles north of Huntington Beach. Owl Rock Products Company obtains aggregate from sandstone and conglomerate of the Eocene Sespe Formation in Gypsum Canyon. In Riverside County, Owl Rock Products processes aggregate from sandstones of the Pliocene Puente Formation, about a quarter of a mile northwest of Prado Dam. Several of the bedrock deposits in the study area present special problems for mining and processing, including the presence of reactive material and high waste, and the necessity of blasting for excavation.

Extraction and processing

All the aggregate produced in the greater Los Angeles area is extracted by surface mining methods. Extraction begins by removing overburden (generally only a few feet in depth) with a bulldozer. This is followed by the vertical and lateral removal of material to form a pit. The pit may be developed either with a uniform slope of 45° or less, or in deeper pits, with a series of 40-foot high "steps" which are offset with level berms so that the total vertical to horizontal ratio does not exceed 1:1.

Several different types of equipment are used for mining and removal of material, including bank draglines, power shovels, front end loaders, and bulldozers. The choice of equipment for any particular operation is influenced by such considerations as dimensions of the pit, daily output, induration of material, position of the water table and personal bias of the operator. The areal extent of the pits in the districts range from 2 to more than 225 acres. Excavations range in depth from a few feet in creek bottoms to more than 250 feet in the alluvial fan at Irwindale. Materials are transported from pits to processing plants by truck, conveyor belt, or (rarely) by dragline scraper.

In most of the aggregate processing operations, bank run material is fed through a coarse grizzly where boulders larger than 6 to 8 inches are diverted and reduced in a jaw crusher (figure 7). The crushed material is moved on a conveyor belt to rejoin the uncrushed material in the jaw feed surge pile awaiting all further processing by various screening, crushing, and washing machinery (figure 7).

In other operations, the bank run material is passed over a scalper screen and the oversize (typically +1-1/2 to 3 in.) is reduced in a cone crusher, followed by dry vibratory screening to produce various sizes of crushed rock ranging from 1-1/2 in. down to dust size particles. The crushed rock is used for asphaltic concrete, base, and subbase. The undersize (minus 1-1/2 in.) from the scalper screen is washed as it passes over a series of vibrating screens, to produce uncrushed gravel and sand, typically in sizes from 1-1/2 to 3/8 inches. These products are used for portland cement aggregate and plaster sands.

In a few districts, heavy media and jigs are employed to remove chemically reactive or poorly indurated materials. In other districts, log washers are used to loosen and remove interstitial clay.

Wash water carrying the removed clay and silt out of the plants, passes into settling ponds where particulate matter settles and the clarified water either percolates into the ground or is pumped back to the plant for reuse.

Environmental and Land use considerations

There are major environmental considerations to be dealt with in quarrying and processing materials for aggregate. These include water use and pollution, air pollution, noise abatement, public safety, esthetics, and land use. In all these areas the aggregate industry must meet rigorous requirements established by the cities, counties, special districts, and the state.

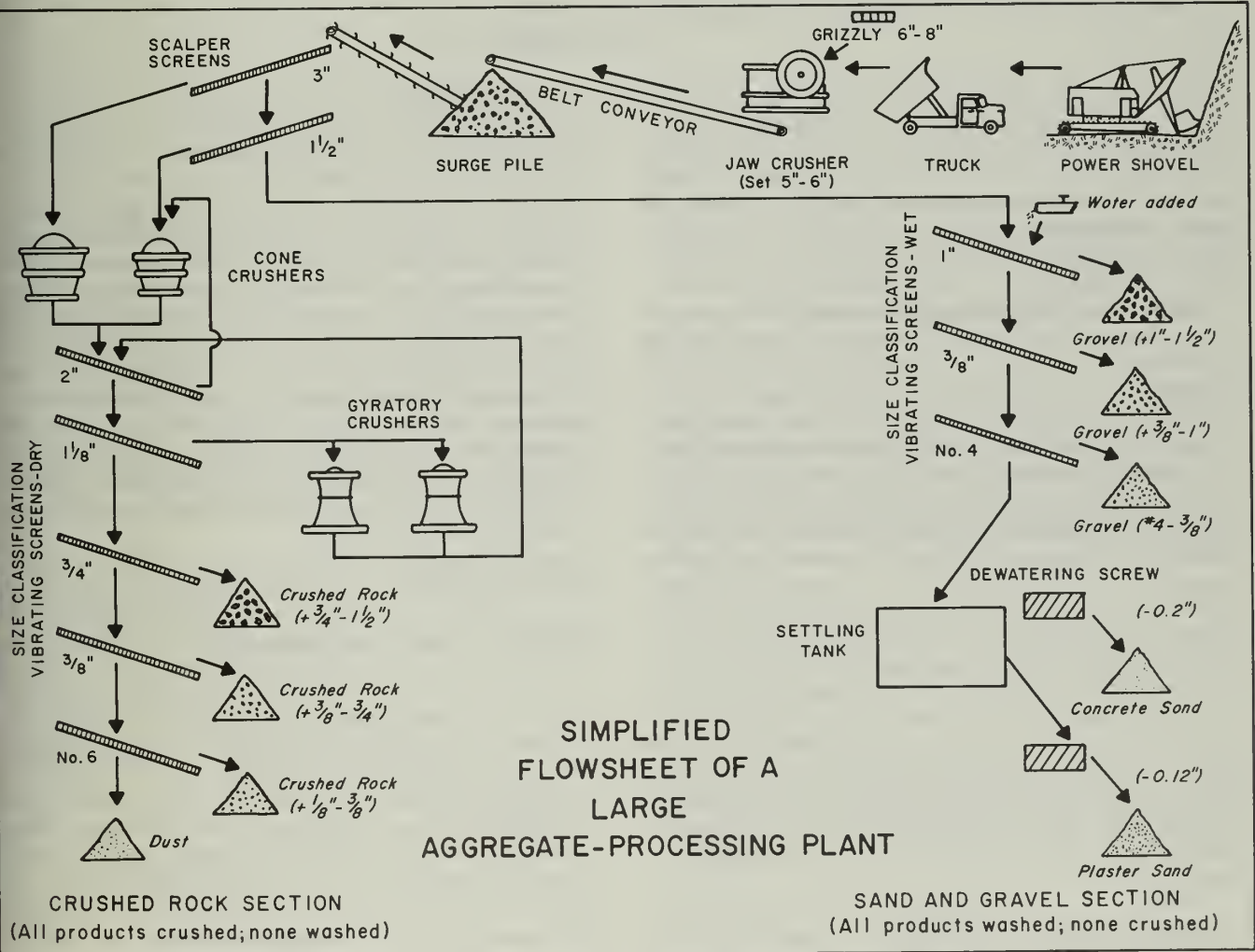


Figure 7. Generalized flowsheet of a typical plant producing sand and gravel from alluvial deposits. By varying size, number, and position of screens, and adjusting crusher settings, a variety of materials can be produced.

A large volume of water is needed to process aggregate. Most of the companies obtain water from wells on their own property. After the water passes through the plant, it goes to settling ponds to let particulate matter settle. Most operations continuously reuse most of their wash water throughout the plant cycle and thus minimize the use of new "makeup" water from wells.

Dust is controlled by periodically spraying the roads with water or oil, and rock crushers are outfitted with spray devices. Many companies require that all trucks and loads be sprayed before leaving the yard.

Noise is abated by restricting operations to daylight hours, by installing sound-barrier walls and berms, and by locating most processing plants away from residential areas. Most pit and delivery trucks must have mufflers to reduce engine noise.

For safety, most operations have fences or walls to prevent unauthorized entry, especially by children. Traffic movement from the plants is regulated to protect pedestrians and others.

One important environmental consideration involves the very presence of a pit or plant. Many people object to these because they believe them to be unsightly. Many companies have undertaken beautification and screening measures to alleviate this problem by building walls and berms, and by planting wide lawns, trees or shrubbery as screens or buffers.

Public concern for reclamation of mined out areas led to the Surface Mining and Reclamation Act of 1975 for the State of California. The Act recognizes the necessity of mining mineral raw materials as well as the importance of minimizing any adverse effects to the environment caused by mining activities. The Act requires the classification of the urbanizing areas of the State and other areas specified by the State Mining and Geology Board, according to their mineral content, so that areas with potential mineral deposits may be protected by land-use planning processes for future mining. The Act provides for three essential concerns with respect to all the State's active mines and quarries: (1) to minimize environmental effects of mining, and to restore the land to a usable form; (2) to encourage production and conservation of minerals with due regard to values relating to recreation, watershed, wildlife range and forage, and aesthetic enjoyment; and (3) to remove residual hazards to public health and safety. Under this Act, aggregate-producing organizations are required to submit plans to local government for the rehabilitation of their pits, and to obtain permits to excavate.

Several deep pits in the greater Los Angeles area have major environmental problems, and acceptable solutions are being sought for them. The aggregate industry has developed numerous effective solutions for the reclama-

tion of depleted pits. Some of these solutions have returned the mined-out land to a higher use than it had prior to mining, with large economic advantage. For example, some pits are now used as spreading basins for ground water recharge and flood control. Others are used for sanitary fill, with restoration of the land to uses indistinguishable from the surroundings. Recreational lakes, golf courses, and similar developments have been built over these sites as intermediate uses until compaction is satisfactory for standard construction.

A number of imaginative plans for reclamation of depleted pits are presently being considered, including use as agricultural production land, fish farms, and wildlife conservation sites. With thoughtful regional land use planning, carefully staged quarrying and concurrent reclamation actions, and public acceptance of a reasonably long period of phased reclamation, most depleted pits can be assured of reclamation to conditions of real value to our present society and to posterity.

Aggregate Production Districts in the Greater Los Angeles Area

The aggregate producing localities in the study area were grouped for purposes of this study into 10 producing districts (figure 1). Field investigations of these districts show that each producer processes material originating from one of four natural types of geologic features: stream channels, floodplains, alluvial fans and bedrock. It would be possible to classify each producing locality according to the geology of its raw material, or to subclassify the 10 producing districts according to the geology of their individual deposits, but to do so would result in some districts with so few producers that a study of them could not be conducted without jeopardizing the confidentiality of company data. Consequently, some producers have been grouped together on the basis of both geographic proximity and geology of the raw material. The resulting 10 production districts are described in this section on a county by county basis.

Los Angeles County

Little Rock Creek Fan production district

General Data: The Little Rock Creek Fan production district is located approximately 40 miles north of the Los Angeles Civic Center (figures 1 and 8). The earliest recorded production for this district was in 1952 (Gay, 1954, p. 538), when John M. Ferry Rock Products and Transit Mix Concrete Products Company were in production. Since 1952, a number of companies have produced from this area, including Terminal Rock Company, Arrow Sand and Gravel Company, Triangle Rock Products, Rockway, Inc., and Blue Diamond Materials. In 1976, three companies were active in this area: Antelope Valley Aggregates, Quality Aggregates, Inc., and Conrock Company (table 4).

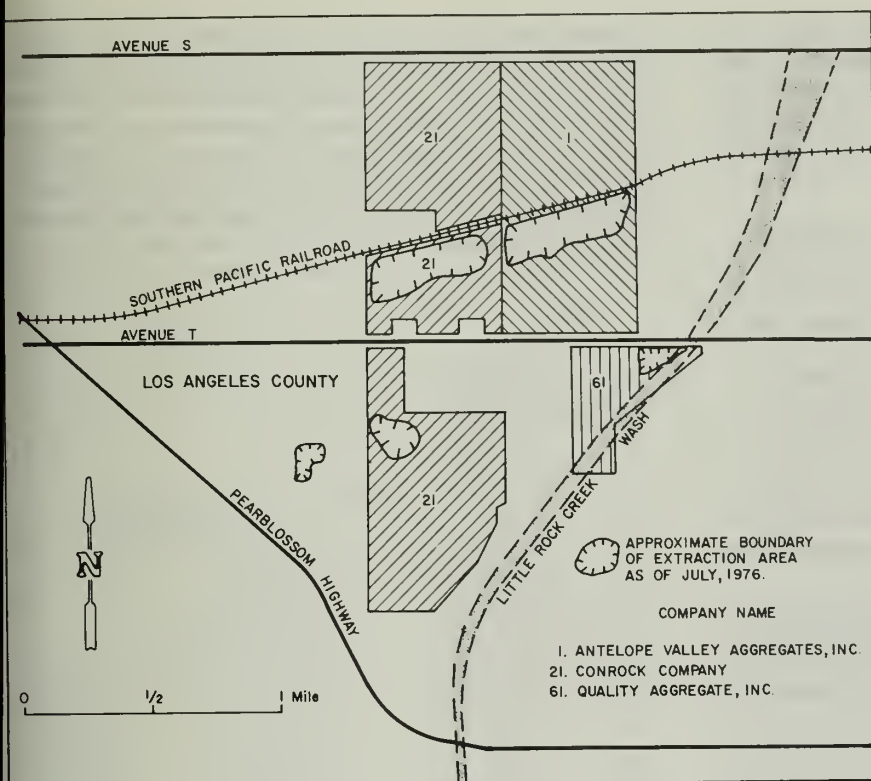


Figure 8. Little Rock Creek fan production district (See Figure 1): Sketch map showing land owned or leased by aggregate companies as of July 1976.

Geology: Aggregate in this district is mined from an alluvial fan that has formed at the northern base of the San Gabriel Mountains about 7 miles southeast of Palmdale. Source material originates from the San Gabriel Mountains where elevations exceed 8,000 feet above sea level. During periods of high rainfall, large volumes of granitic rock, feldspathic gneisses and schists, gabbroic rock, and mafic volcanic detritus are transported for distances as much as 18 miles along the mountain drainage courses of Little Rock Creek to the edge of Antelope Valley where the creek debauches to form an alluvial fan. The coarsest material is deposited near the base of the mountains.

The fan extends about 5 miles in a northerly direction from the base of the mountains. Little Rock Creek wash flows through and past the fan, and can be traced for at least 6 more miles. The fan attains a maximum width of 4 miles and has an average slope of 50 feet per mile from

its head. Drill hole data (Thompson, 1929, p. 338) indicate that the minimum thickness of the fan at the base of the mountains is 80 feet, and that at its northern edge the thickness of the fan increases to over 250 feet. The subsurface extent of commercially acceptable material in the fan is unknown.

The deposit is poorly sorted, with coarse aggregate making up about 60 percent of the material where it is being mined. Bedding is poorly developed, although thin beds of sand are dispersed throughout the deposit and a minor amount of clay is present. The deposit is considered a desirable source of aggregate because particle sizes vary widely and reactive rock and weak material are generally absent.

Production and Marketing Data: The three plants operating in the district (table 4) averaged 300,000 tons of out-

Table 4. Little Rock Creek fan production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
1	Antelope Valley Aggregates, Inc.	Littlerock	S1 T5N R11W	Alluvial Fan	65	600	C,A,B,F
21	Conrock Company	Palmdale	S2,11 T5N R11W	Alluvial Fan	62	300	C,A,B
61	Quality Aggregates, Inc.	Littlerock	S11,12 T5N R11W	Alluvial Fan	52	300	C,P

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)

** See Figure 1

put in 1975, while the individual plants produced from 280,000 to more than 475,000 tons. They produced washed concrete sand, plaster sand, gravel, unwashed sand, dust, crushed rock, base and fill. It is estimated that the production was utilized and sold approximately as follows:

Product Use	Percentage	F.O.B. Price Range (ton)
Concrete	20%	\$2.60
Asphalt	30%	\$2.65–\$2.70
Base	25%	\$2.60–\$2.65
Fill	25%	\$1.05–\$1.50

This production was marketed in the Palmdale–Lancaster–Pearblossom region, with an occasional order sold in Victorville, Tehachapi, and China Lake. It all was shipped by truck.

In 1975, over 680,000 tons of processed aggregate was produced and sold (table 5). During the five year period 1971–1975 annual production averaged 963,000 tons (figure 9). Since 1960, the district has produced slightly over 16,000,000 tons of aggregate, which represents 2.3 percent of the total output of the entire study area for that period (table 5).

Table 5. Little Rock Creek fan production district: Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	589,260
1961	290,632
1962	282,263
1963	600,000
1964	675,000
1965	987,000
1966	1,271,000
1967	1,392,000
1968	1,554,000
1969	2,089,553
1970	1,686,441
1971	1,383,829
1972	1,161,984
1973	904,854
1974	675,364
1975	688,497
TOTAL	16,231,677

Extraction and Processing: The three active producers in this area extract sand and gravel from pits that range in size from about 10 to 40 acres, but which average about 28 acres. The maximum mining depth reached in the district is slightly deeper than 80 feet.

Aggregate is excavated using bulldozer and front end loaders. However, Antelope Valley Aggregates, Inc. at

various times in the past has used a dragline for mining. Conveyor belts, a bottom dump truck, and a front end loader are used to deliver material from the pits to the processing plants. The sand and gravel is then subjected to conventional crushing, sizing and washing to produce both washed and unwashed products. Combined waste from mining and processing does not exceed 15 percent for the district.

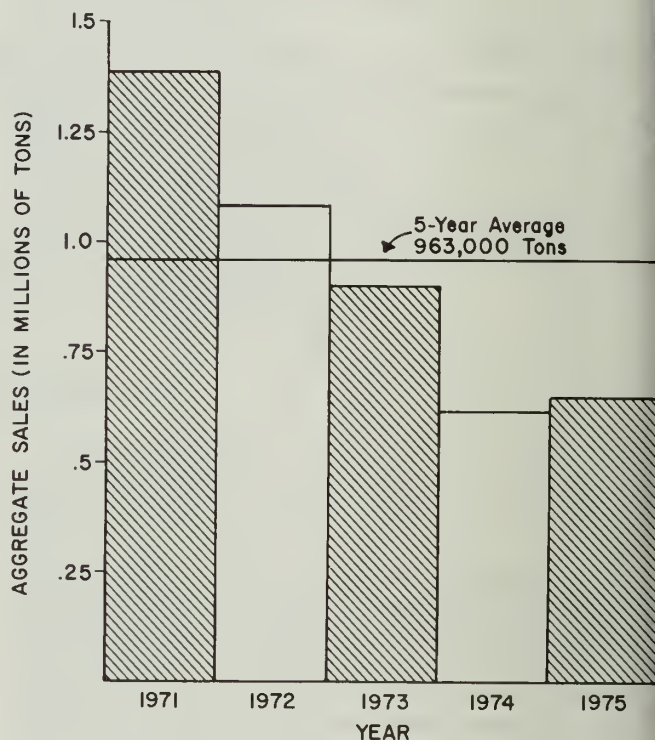


Figure 9. Little Rock Creek fan production district: Aggregate sales from 1971 through 1975.

Reserves and Resources: Factors that determine reserves for the district are outlined below.

1. Setbacks from property lines, roads and railroads range from 50 to 200 feet.
2. Pit wall slopes vary from 1:1 to 2:1 (horizontal to vertical ratio).
3. A change of quality from acceptable to marginal grade material at 80 feet constrains mining to that depth for the district.
4. Bulk, in-place material density is estimated to be .065 tons per cubic foot.
5. Waste ranges from 5 to 10 percent.

Taking into account the above factors, it is estimated that about 100 m.t. (million tons) of indicated reserves and 600,000 tons of inferred reserves were present within

lands owned or leased by the three active companies in 1976 (table 6). The adjusted total reserves are about 80 million tons. Indicated resources are over 15 m.t., and the inferred resources are about 20 m.t. The adjusted total resources are over 24 m.t. Based upon the average rate of sales (production) from 1971 through 1975, sufficient reserves exist to sustain more than 83 years of production. If all the resources are converted to the reserve category, it would add about 27 years more life to the district.

TABLE 6. Little Rock Creek fan production district: sales, reserves, and length of life for the district.

1975 Total Sales*	688,000
1971-1975 Average Annual Sales*	960,000
Total Reserves*	$\begin{matrix} 100 \text{ m.t. (In)} \times 0.8 = 80 \text{ m.t.} \\ + 0.6 \text{ m.t. (If)} \times 0.6 = \frac{0.36}{\text{adjusted:}} \\ \hline 80 \text{ m.t.} \end{matrix}$
** M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	$\begin{matrix} 15 \text{ m.t. (In)} \times 0.8 = 12 \text{ m.t.} \\ + 20 \text{ m.t. (If)} \times 0.6 = \frac{12}{\text{adjusted:}} \\ \hline 24 \text{ m.t.} \end{matrix}$
Estimate Life of District Based on 1975 Adjusted Reserves	$80 \text{ m.t.} \div 0.96 \text{ m.t./yr} = 83 \text{ yrs}$
Estimated Extended Life of District if all Resources are Converted to Reserves	$(80+24) \text{ m.t.} \div 0.96 \text{ m.t./yr} = 110 \text{ yrs}$

* Short Tons
** See Reserve and Resource Calculation Factors Section

Land and Water Use: Permits to extract aggregate in this district are under the jurisdiction of the County of Los Angeles. The properties have been classified variously as M2, M3 and Q zones.³ Setbacks of 50 feet adjacent to Avenue T and the highway are specified in the use permits. Slopes cannot exceed a ratio of 1:1 (horizontal to vertical distance). No depth limitations to mining are specified in the permits.

About 45 acre-feet of water per month is used for processing aggregate, all obtained from company-owned wells. After water has passed through the plant, it goes into settling ponds for clarification and then is recycled back into the plant or returned to the water table through percolation.

Environmental Considerations: Comparatively few environmental problems are caused by aggregate mining and processing in this district. The operations are sufficiently removed from populated areas that they are not a significant source or irritation to the public. Normal operating procedures are followed, such as controlling dust, enclosing the property with a fence, and confining production to daylight hours. None of the pits in the district have been reclaimed, and no formal plans had been developed for pit reclamation in 1976.

San Gabriel Fan production district

General Data: This district is located 18 miles northeast of the Los Angeles Civic Center (figures 1 and 10). Of all the districts in the study area, it is the largest supplier of aggregate.

No known records indicate when sand and gravel were first extracted from the San Gabriel fan, but it was probably prior to 1900. Pacific Rock and Gravel Company (Gay and Hoffman, 1954, p. 538) mined and processed aggregate during the period 1909 to 1922. Eight producers were processing material extracted from the San Gabriel fan in 1976 (table 7).

Geology: Aggregate is mined from an alluvial fan developed at the southern base of the San Gabriel Mountains.

Table 7. San Gabriel fan production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
2	Azusa Western	Azusa	Azusa S3,4,33,34 T1S R10W	Alluvial Fan	70	1250	C,A,B
7	Blue Diamond Materials	Santa Fe	Irwindale S1,2 T1S R11W	Alluvial Fan	60	1500	C,A,B
8	Blue Diamond Materials	Sierra	Irwindale S2,11 T1S R11W	Alluvial Fan	60	(none)	C,A,B
18	Conrock Company	Durbin	Irwindale S13 T1S R11W	Alluvial Fan	45	1200	C,A,B,F
22	Conrock Company	Reliance	Irwindale S4,28,32,33 T1N R10W	Alluvial Fan	60	1400	C,A,B,F
45	Livingston-Graham, Inc.	Duarte	Irwindale S36 T1N R11W	Alluvial Fan	70	275	C,A,B,F,P
46	Livingston-Graham, Inc.	El Monte	Irwindale S1,2,11,12 T1S R11W	Alluvial Fan	65	2500	C,A,B,F,P
50	Manning Brothers Rock & Sand Company	Irwindale	Irwindale S9 T1S R10W	Alluvial Fan	60	400	C,A,B
52	Owl Rock Products Company	Azusa	Azusa S22,27 T1N R10W	Alluvial Fan	70	1200	C,A,B

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)
** See Figure 1

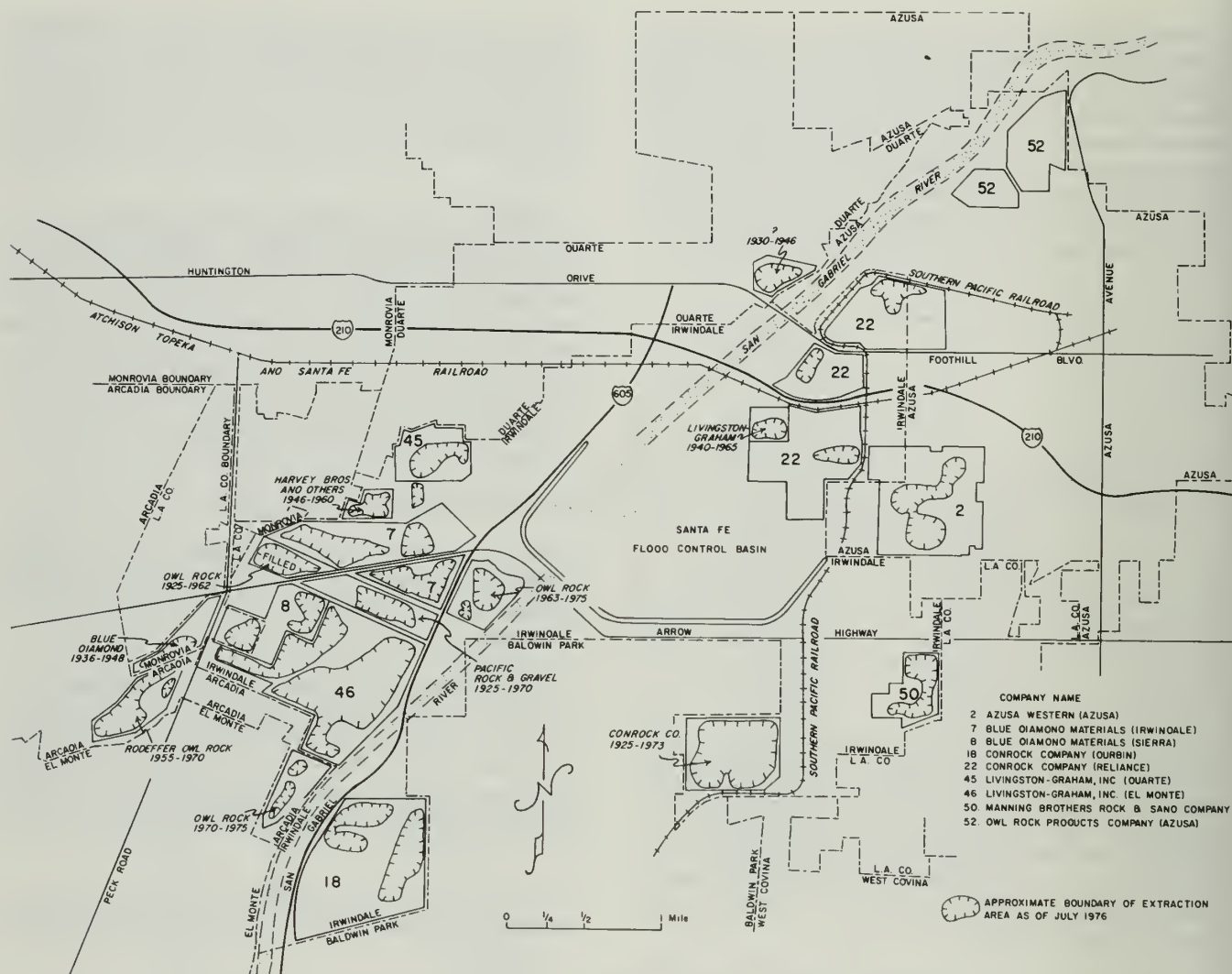


Figure 10. San Gabriel fan production district (see Figure 1): Sketch map showing land owned or leased by aggregate companies as of July 1976.

The fan extends about eight miles in a southwesterly direction and attains a maximum width of approximately four miles near its base. Its surface gradient averages 50 feet per mile. Material acceptable for aggregate is deeper than 200 feet at the head of fan, and deeper than 900 feet at its southern extent. The lowermost limit of commercially acceptable material has not been established.

The detritus in the fan is derived from the igneous and metamorphic complex that makes up the San Gabriel Mountains to the north, where elevations exceed 9,000 feet above sea level. During periods of high rainfall, large volumes of detritus composed of granite, grano-diorite, diorite, granitic gneiss, schist and vein quartz are carried into the drainage system. The detritus is transported by the San Gabriel River and its tributaries as far as 22 miles from its source area to the site of deposition. The coarser particles tend to be deposited near the head of the fan, while the finer grained particles are carried farther down-

stream before they are deposited. The deposit is poorly sorted, with particles coarser than 4 millimeters ranging from 45 to 70 percent. Boulders larger than 8 feet are found near the head of the fan, and thin sand lenses that represent old channel fill are relatively common.

The deposit is considered by producers to be very desirable as a source of aggregate because it contains a wide variety of particle sizes, is durable material, has little or no reactive or weak particles, and a low proportion of waste.

Production and Marketing Data: The eight active plants in the district produced an average of 1.5 million tons of aggregates in 1975 (table 7). Individual plants produced from 0.5 to over 3.0 million tons, including washed concrete sand, plaster sand, gravel, unwashed sand, dust, crushed rock, base and fill. It is estimated that the production is sold and utilized as follows:

Product Use	Percentage	F.O.B. Price Range (ton)
Concrete	55%	\$2.60-2.70
Asphalt	18%	\$2.50-2.85
Base	23%	\$2.10-2.95
Fill	4%	\$1.25-1.70

Production from the San Gabriel Fan production district is marketed in eastern Los Angeles County, including the Civic Center, and in Orange and Santa Barbara Counties. All the aggregate is shipped by truck except for a minor amount that moves by rail into Santa Barbara County.

In 1975, more than 12 million tons of processed aggregate were sold from production in this district (table 8). Over the five-year period 1971-1975 average total sales from the district exceeded 14 million tons per annum (figure 11). Since 1960, the district has produced almost 240 million tons of aggregate, which represents about 34 percent of the output for the entire study area (table 8).

Table 8. San Gabriel fan production district: Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	9,364,577
1961	13,824,465
1962	15,374,955
1963	15,965,847
1964	16,138,943
1965	15,492,300
1966	18,459,595
1967	14,893,093
1968	15,908,329
1969	14,210,436
1970	16,438,663
1971	15,071,344
1972	15,053,384
1973	16,703,879
1974	13,142,764
1975	12,399,240
TOTAL	238,441,814

Extraction and Processing: Eight plants produced aggregate in this district in 1976, from pits which measured from 18 to over 300 acres, but averaged 110 acres. Depths of pits ranged from 50 to 250 feet, with the average about 150 feet.

Power shovels and front end loaders are the most common excavation equipment in the district; bank draglines are less common. Pits are excavated by bench or slope cuts, with banks commonly having a 1:1 horizontal to vertical ratio.

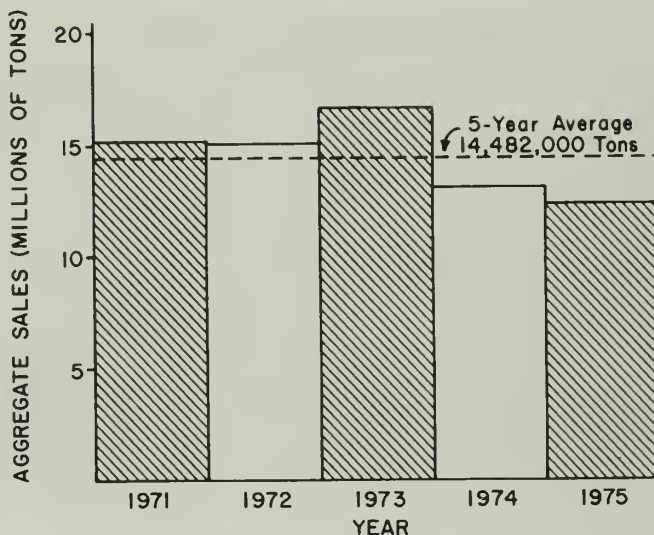


Figure 11. San Gabriel fan production district: Aggregate sales from 1971 through 1975.

Raw material from the pits is treated in plants employing both wet and dry circuits. There the aggregate is subjected to primary crushing, then secondary crushing, followed by washing, classification and stockpiling into appropriate sizes.

Reserves and Resources: Factors used in determining reserves in this district are:

1. Minimum setbacks from property boundaries range from 25 to 200 feet.
2. Pit wall slopes range from 1:1 to 2:1 (horizontal to vertical ratio).
3. Maximum pit depths of 150 feet exist in the City of Irwindale and 200 feet in the City of Azusa.
4. Material density is estimated to be .065 tons per cubic foot.
5. Waste, representing overburden and fine material discarded during processing, ranges from 5 to 10 percent.

Taking into account the above factors, it is estimated that about 180 m.t. (million tons) of measured and 190 m.t. of indicated reserves exist in the district as of July 1976 (table 9). The adjusted total reserves are about 330 m.t. Measured resources are about 47 m.t. and the indicated resources more than 190 m.t. The adjusted total resources are slightly over 200 m.t. Based upon the average rate of production from 1971 to 1975, sufficient reserves exist in the district to sustain about 23 years of production. If all resources were converted into reserves, it would add about 14 years of life to the district.

Published drill hole data (California Department of Water Resources, 1966) shows that aggregate extends to a depth of at least 150 feet beneath much of the San Gabriel alluvial fan. Because most of this is beneath ur-

TABLE 9. San Gabriel fan production district: sales, reserves, and length of life for the district.

1975 Total Sales*	12,400,000
1971-1975 Average Annual Sales*	14,480,000
Total Reserves*	$180 \text{ m.t. (M)} \times 1.0 = 180 \text{ m.t.}$ $+ 190 \text{ m.t. (In)} \times 0.8 = 150$ adjusted: 330 m.t.
** M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	$47 \text{ m.t. (M)} \times 1.0 = 47 \text{ m.t.}$ $+ 190 \text{ m.t. (In)} \times 0.8 = 150$ adjusted: 200 m.t.
Estimate Life of District Based on 1975 Adjusted Reserves	$330 \text{ m.t.} \div 14.5 \text{ m.t./yr} = 23 \text{ yrs}$
Estimated Extended Life of District if all Resources are Converted to Reserves	$(330+200) \text{ m.t.} \div 14.5 \text{ m.t./yr} = 37 \text{ yrs}$

* Short Tons

** See Reserve and Resource Calculation Factors Section

banized lands and outside producing areas, virtually nothing is known of its quality.

Land and Water Use: Aggregate mining and processing operations are regulated by zoning restrictions of the several communities in the district, including the cities of Irwindale, Azusa, and Arcadia. Because some of the operating companies have property that crosses boundaries, between two or more cities, a use permit is required from each jurisdiction. As an example, the El Monte operation of Livingston Graham Inc. is subject to the various regulations of Irwindale, Azusa and Arcadia. Irwindale generally sets a limit of 150 feet to the depth of mining, but Azusa has not established a depth limit.

Company owned spreading-basin areas occupy a large area in the district, and have a definite effect on mining operations. For example, adjacent to the Irwindale Avenue spreading grounds, pit slopes cannot exceed 2:1 (horizontal to vertical ratio). Also, tailings from mining must be disposed of in a manner that will not prevent normal percolation of ground water into the water table, nor can the pits be backfilled with any material that would be deleterious to ground water quality.

Each month approximately 675 acre-feet of water used by all the aggregate processing plants in the district for processing aggregate and controlling dust. Most of this comes from company-owned wells. After passing through the plant and into settling ponds, much of this water is either reused on the premises or percolates back through the ground to the water table.

Environmental Considerations: Environmental considerations for the district are similar to those for the entire study area. Flood control and water storage is of major importance to this district. A considerable amount of land that had previously been used for aggregate mining is now used for flood control and as spreading basins. It is anticipated that when Owl Rock Products Company terminates mining operations at its Azusa property, the property will be used for water spreading and conservation. Livingston-Graham Inc. has developed rehabilitation plans for their Duarte and El Monte plants, which include converting these properties into a golf course and recreation lake, respectively. The plans envision partial landfill of the expended pits, and building a low-profile industrial center, restaurant, and retail commercial center. Other products in the district are examining various plans for rehabilitating their pits after operations have ceased.

Tujunga Fan production district

General Data: This district is located in the San Fernando Valley, 15 miles northwest of the Los Angeles Civic Center (figures 1 & 12). Aggregate is mined from the Tujunga alluvial fan at the base of the San Gabriel Mountains near the mouth of Big Tujunga Canyon.

The earliest operations in this district were in the first decade of the century and possibly much earlier. In 1909 Tujunga Rock Company was operating here, and Tucker reported (1927, p. 333-340) that 10 companies were producing from the district in 1927. In 1976, four operators were active in the district (table 10).

Table 10. Tujunga fan production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
15	Conrock Company	Boulevard	S24,25 T2N R15W	Alluvial Fan	15	100	B,O
16	Conrock Company	Cal Mat	S19,20 T2N R14W	Alluvial Fan	70	500	C,A,P
26	Conrock Company	Sun Valley	S18,29,30 T2N R14W	Alluvial Fan	50	1,300	C,A,P,O
49	Livingston-Graham, Inc.	Sun Valley	S19,30 T1N R14W	Alluvial Fan	70	300	C,B,F

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)

** See Figure 1

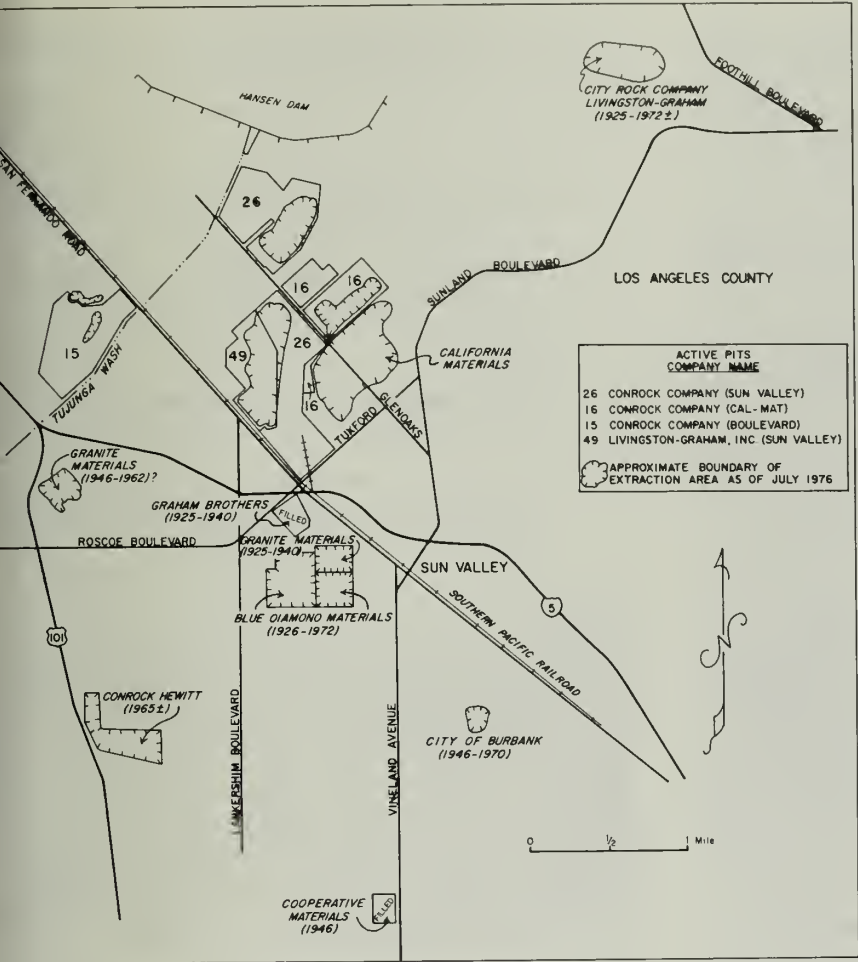


Figure 12. Tujunga fan production district (see Figure 1): Sketch map showing land owned or leased by aggregate companies as of July 1976.

Geology: Materials that make up the alluvial fan originate from the San Gabriel Mountains to the northeast, where elevations exceed 6,000 feet. Material is transported along the Big Tujunga Wash and its associated alluvial fan as far as 24 miles from the source to a site of deposition. The fan material is composed of granitic rocks and a variety of felsic gneisses and schists. The coarsest material is deposited near the head of the alluvial fan, while the smaller sizes tend to be transported farther toward its base.

From its head, near the mouth of Big Tujunga Canyon, the fan can be traced for approximately six miles in a southwesterly direction. The fan attains a maximum width of about five miles at its base and its surface gradient averages 40 feet per mile. Commercially acceptable aggregate is present to depths ranging from 135 to more than 200 feet. It is poorly sorted, with coarse material making up from 15 to 70 percent of the bank-run material at the several active pits.

The wide variation in particle sizes, the general absence of reactive rock, and the small proportion of weak rock in the material from this district makes it a good source of aggregate.

Production and Marketing: In 1975, four plants in the district (table 10) had a total output of over 4 m.t. (million tons), with individual plants producing from about 120,000 to nearly 3 m.t. of aggregate. Materials produced include concrete aggregate, crushed rock, washed concrete sand, plaster sand, gunite sand, dust, fill and base. It is estimated that the production was sold and utilized as follows:

Product Use	Percentage	Price
		Range (per ton)
Concrete	60%	\$2.60-3.25
Asphalt	30%	\$2.55-3.00
Base	5%	\$2.55-2.80
Fill	2%	\$2.20-2.45
Plaster	3%	\$3.05

Most of the output of this district is trucked to the Sun Valley-Van Nuys area, the downtown Los Angeles area, and the area centered about the Santa Monica-San Diego freeway interchange.

During 1975, more than 4.3 m.t. of processed aggregate were sold (table 11). Over the five-year period 1971-1975 the average annual total sales from the district exceeded 4.4 m.t. (figure 13). Since 1960, the district produced almost 85 m.t. of finished aggregate, which represents over 12 percent of the total output for the study area (table 11).

Extraction and Processing: The four active companies produce aggregate from pits that range in size from approxi-

Table 11. Tujunga fan production district:
Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	5,169,730
1961	5,818,943
1962	6,668,742
1963	6,772,488
1964	6,858,000
1965	5,883,000
1966	5,832,000
1967	5,023,000
1968	5,188,000
1969	4,545,392
1970	4,327,659
1971	4,629,676
1972	4,671,359
1973	4,642,441
1974	4,207,796
1975	4,324,988
TOTAL	84,563,214

mately 5 to over 100 acres. Pit depths range from 35 to 200 feet, with most of the production coming from the deeper pits. In this district, all material is mined by bank draglines, except at the Conrock Company Boulevard pit where a Caterpillar loader is used. Belt conveyors transport bank-run material to the plants, except for the Livingston Graham Company which uses 25- and 36-ton off-highway vehicles. At the Conrock Company's Sun Valley operation, aggregate is moved approximately two miles by conveyor, the longest conveyor haul in the study area.

The Livingston Graham Company operation at Sun Valley is unique in that it relocated its processing plant in a mined-out section of the existing pit. Thus, they can mine out the block of ground beneath the former plant site. This is a good conservation practice: it increases the recoverable reserves within the property boundaries.

Operators in the district process aggregate in conventional wet and dry circuits. An exception is the Boulevard plant of Conrock Company, where only a dry circuit is employed. Combined waste from mining and processing varies from 5 to 25 percent for the district, with most operations being closer to the lower figure.

Reserves and Resources: Factors used in computing reserves for this district include:

1. Minimum setbacks from property lines range from 50 to 80 feet.
2. Depth of mining ranges from 100 to 200 feet, with most pits near the deeper figure.
3. Material density is estimated to be .065 tons per cubic foot.
4. Slopes vary from 1:1 to 1-1.5:1 (horizontal to vertical ratio).
5. Waste, representing overburden and fine material discarded during processing, ranges from 5 to 10 percent.
6. Technological constraints that locally affect the depth of mining include the position of the bedrock contact with alluvial fan material and the presence at shallow depth of layers of clayey silt that is unacceptable as aggregate.

Taking into account the above factors, it is estimated that in 1976 the district had 33 m.t. (million tons) of measured reserves and 25 m.t. of indicated reserves (table 12). The adjusted total reserves exceed 53 m.t. Measured resources are about 12 m.t., while the indicated resources are slightly over 11 m.t. and the inferred resources are 15 m.t. This gives an adjusted total resource of 30 m.t. Based upon the average rate of production from 1971 to 1975, reserves are adequate to sustain 12 years of production by the district. If all the resources are converted to reserves, it would add six years of life to the district.

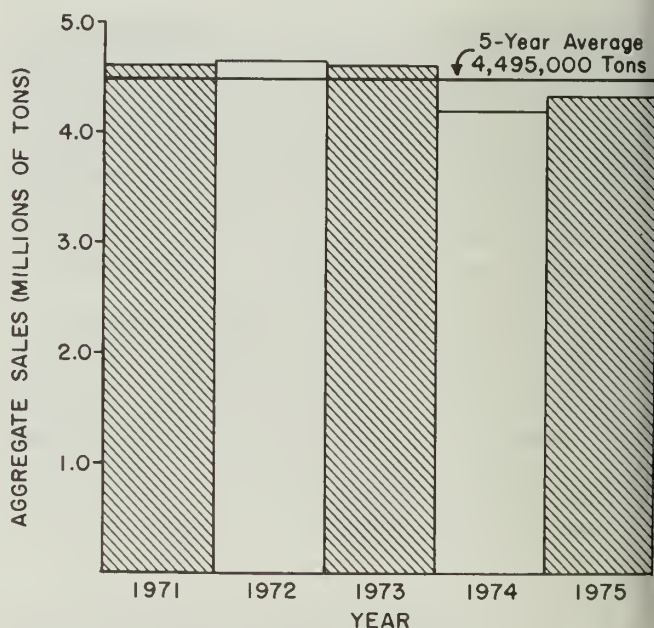


Figure 13. Tujunga fan production district: Aggregate sales from 1971 through 1975.

TABLE 12. Tujunga Creek fan production district: sales, reserves, and length of life for the district.

1975 Total Sales*	4,325,000
1971-1975 Average Annual Sales*	4,500,000
Total Reserves*	$33 \text{ m.t. (M)} \times 1.0 = 33 \text{ m.t.}$ $+ 25 \text{ m.t. (If)} \times 0.8 = 20$ adjusted: 53 m.t.
** M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	$12 \text{ m.t. (M)} \times 1.0 = 12 \text{ m.t.}$ $+ 11 \text{ m.t. (In)} \times 0.8 = 8.8$ $15 \text{ m.t. (If)} \times 0.6 = 9.0$ adjusted: 30 m.t.
Total Resources*	
Estimate Life of District Based on 1975 Adjusted Reserves	$53 \text{ m.t.} \div 4.5 \text{ m.t./yr} = 12 \text{ yrs}$
Estimated Extended Life of District if all Resources are Converted to Reserves	$(53+30) \text{ m.t.} \div 4.5 \text{ m.t./yr} = 18 \text{ yrs}$

* Short Tons

** See Reserve and Resource Calculation Factors Section

A substantial portion of the San Fernando Valley is filled with alluvial material that can be traced to the San Gabriel Mountains. For example, Big Tujunga Wash forms two separate branches below Hansen Dam, that can be traced for more than 11 miles southward where they join the Los Angeles River. Each of these branches is over one-quarter mile wide and contains aggregate. Furthermore, much of the surrounding alluvial fan contains aggregate. Drill logs (California State Water Rights Board, 1960) show sand and gravel present to depths up to 500 feet as far south as 7 miles from Hansen Dam. However, most of the material lies beneath urbanized area.

Land and Water Use: The mining and processing of aggregate in the district is regulated by the City of Los Angeles. Areas which have been zoned M2G and M3G can be utilized for extraction and processing of aggregate. Set-backs of 50 feet, and slopes of 1:1 and 1.5:1 (horizontal to vertical ratio) are required.

Most of the water needed for processing is obtained from company-owned wells located on the respective properties, but some water is purchased from the city. About 150 acre-feet of water is used monthly in mining and processing aggregate. Much of this is reused by the plants after it has passed into settling ponds to remove

particulate matter. The balance is allowed to seep back into the ground water table, except for minor amounts lost to evaporation.

Environmental Considerations: This district is confronted with the same environmental considerations that were discussed for the entire study area. Flood control and water spreading are locally important.

Both active and formerly active pits are being used for sanitary landfill. Currently Class III refuse material (inert) is being dumped into the Bradley pit adjacent to the Sun Valley operation of Conrock Company. A previously filled pit adjacent to Telfair and Penrose Streets is now used as a bus yard by the Southern California Rapid Transit District. No specific end-use plans have been developed for pits within the district although industrial, agricultural and aquaculture uses are under consideration.

Upper Santa Clara River production district

General Data: This district is approximately 30 miles northwest of the Los Angeles Civic Center (figures 1 and 14). Gay and Hoffman (1954, p. 540) report aggregate mining as early as 1948 in this district by MacArthur and Sons about one-half mile west of Lang Siding. The operation produced about 10,000 tons of material yearly. In 1950, A. A. Shirley Ready Mix Concrete was mining from the Santa Clara River bed near Lang Siding. Since 1970, Curtis Construction Company has operated this property.

Presently there are three mining and processing operations in the district, controlled by two companies, P. W. Gillibrand Company and Curtis Construction Company (table 13).

Geology: Aggregate is mined from two distinct types of deposits in this district: (1) the channel deposits of the Upper Santa Clara River; and (2) the older bedrock deposits of the San Gabriel intrusive complex that include conglomerates of the Miocene Mint Canyon Formation and Precambrian gabbro (figure 15).

Sand and gravel occurs throughout the channel of the Upper Santa Clara River, which has its headwaters near the town of Vincent 15 miles to the northeast. Its gradient

Table 13. Upper Santa Clara River production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
29	Curtis Construction Company	Lang Siding	S18 T4N R14W	Stream Channel	40	350	C,B,F
30	Curtis Construction Company	Soledad	S16 T4N R14W	Bedrock	70	400	C,B,F
39	P.W. Gillibrand, Inc.	Soledad	S17 T4N R14W	Bedrock	60	200	A,B,O

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)

** See Figure 1

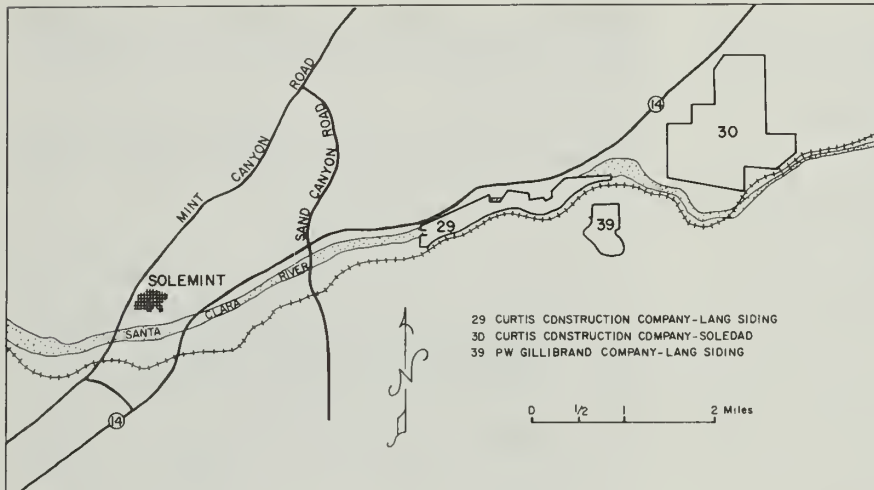


Figure 14. Upper Santa Clara River production district (see Figure 1): Sketch map showing land owned or leased by aggregate companies as of July 1976.

is about 60 feet per mile near Land Siding. Detrital material composed of gabbro, volcanic rocks, several varieties of granite, and felsic schists have been deposited along the river channel. This material originated southward from the San Gabriel Mountains and northeast eight miles from the Sierra Pelona. This deposit is approximately 500 feet wide, and at least 20 feet deep. On an average, it is replenished about every five years by heavy seasonal rainfall. The deposit contains about 40 percent coarse material (larger than one-fourth in. size).

Curtis Construction Company mines Miocene Mint Canyon conglomerate on the north side of Soledad Canyon, about three miles east of the Lang Siding deposit, where the Mint Canyon Formation is composed of sandstone and conglomerate. The deposit is in fault contact to the west with Precambrian San Gabriel anorthosite and gabbro. To the south of the Curtis property, the easterly trending Soledad Canyon fault juxtaposes San Gabriel anorthosite with the conglomerate. The Mint Canyon rocks at this locale are predominantly conglomerate con-

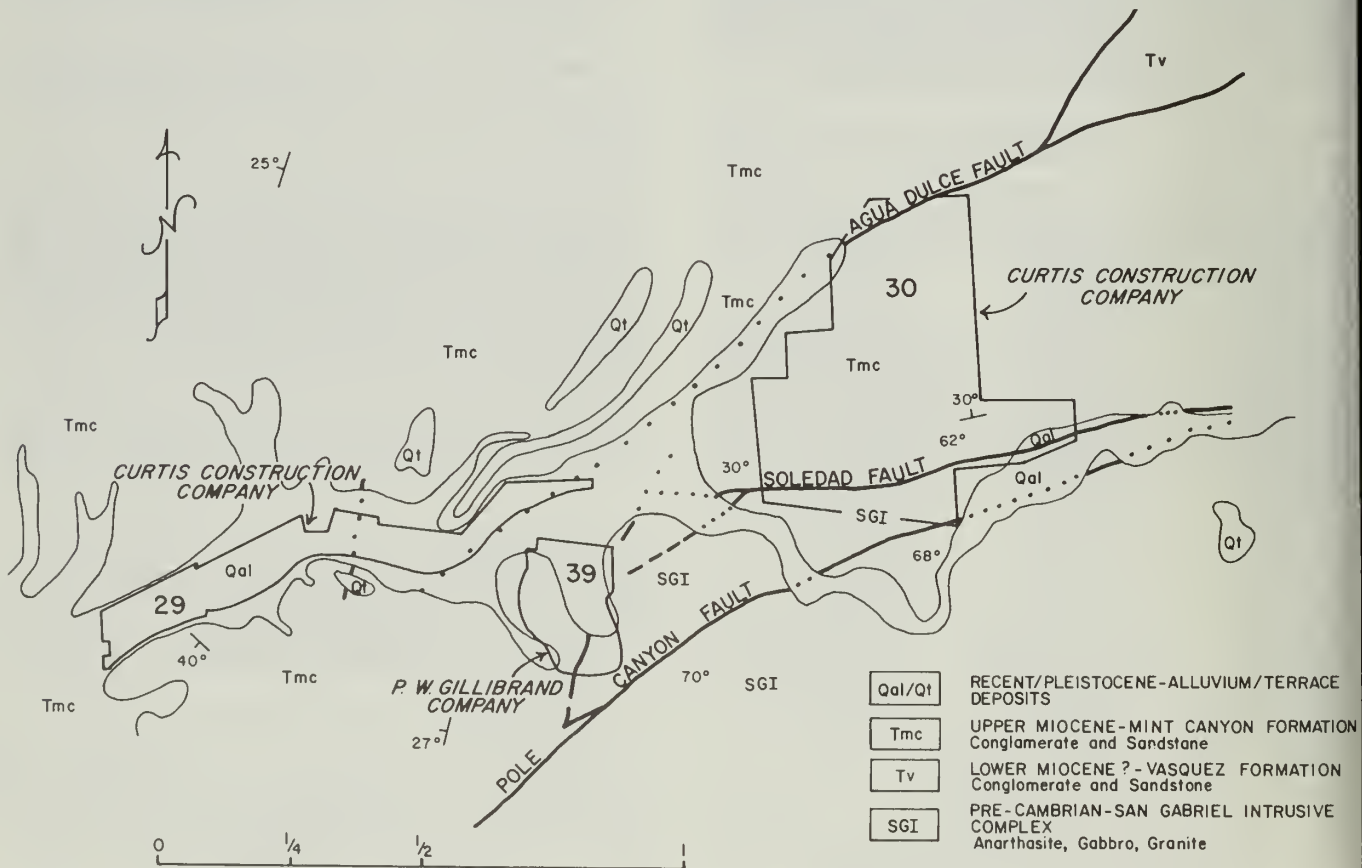


Figure 15. Geology of the Upper Santa Clara River production district.

GEOLOGY MODIFIED FROM OAKESHOTT, G.B., 1958

aining about 60 percent coarse material, mostly gabbro, and several varieties of granitic rocks.

P. W. Gillibrand Company mines from two separate bedrock deposits at its operation about one-half mile east of the Curtis Construction Company's Lang Siding deposit. In Pole Canyon near the eastern border of the Gillibrand property, the company mines gabbro of the Precambrian San Gabriel complex which is typically composed of coarse interlocking crystals of plagioclase, ilmenite, and magnetite. On the weathered surface, and for 10–15 feet below, this material is weak and unsuitable for aggregate. At depths below 15 to 20 feet weathering is much less pronounced, and the material is sufficiently hard to require blasting for removal.

A few hundred feet west of the Pole Canyon quarry, P. W. Gillibrand mines aggregate from conglomerate of the Miocene Mint Canyon Formation. Here the rocks have a shallow dip, are poorly sorted, and contain 60 percent coarse material (greater than one-fourth in.). The clasts in this deposit are granitic gneiss, andesite, and gabbro. Some of these are extensively weathered and unsuitable for aggregate.

Production and Marketing Data: The three plants in this district (table 13) had an average 240,000 tons output in 1975. Individual plants produced 130,000 to 350,000 tons of aggregate. They produced washed concrete sand, washed plaster sand, gunite sand, gravel, crushed rock, base, subbase, and fill. Products are marketed in the Newhall–Saugus–Valencia area and a few miles to the west. The quantities of each product used are not estimated. The price range for the products are:

<i>Product Use</i>	<i>F.O.B. Price Range (ton)</i>
Concrete	\$1.95–2.65
Asphalt	\$1.80–2.65
Base	\$1.50–2.25
Fill	\$1.10–1.50
Plaster	\$3.00–3.50

In 1975, more than 848,000 tons of processed material were sold from the district (table 14). During a five year period, 1971–1975, average annual combined sales of the district have been over 1 m.t. (million tons) (figure 16). Since 1960, the district has produced over 8.5 million tons of aggregate, which represents 1.2 percent of the total production for the entire study area.

Extraction and Processing: Aggregate is mined by the three operating companies from four pit sites (table 13). Three of these are bedrock quarries and the fourth is a pit in the Santa Clara River. Explosives are required for excavating material from the Mint Canyon Formation at Curtis Construction Company's Soledad operation, and gabbro of the San Gabriel complex at P. W. Gillibrand Company's operation. The broken rock at Curtis Construction Company's operation is moved by front-end

Table 14. Upper Santa Clara River production district: Aggregate sales from 1960 through 1975.

<u>YEAR</u>	<u>TONS</u>
1960	233,028
1961	421,425
1962	293,370
1963	190,511
1964	78,000
1965	194,000
1966	162,000
1967	132,000
1968	140,000
1969	388,203
1970	1,091,798
1971	1,035,697
1972	1,324,909
1973	1,029,517
1974	964,607
1975	848,300
TOTAL	8,527,365

loaders to a conveyor belt for transport to the processing plant, whereas gabbroic rock at Gillibrand's plant is hauled in an off-highway vehicle to the plant.

Conglomerate from the Mint Canyon Formation is removed at Gillibrand's operation with a bulldozer and ripper, then loaded by a front-end loader into an off-highway truck for transport to the processing plant. Curtis Construction Company uses a front-end loader to mine aggregate out of the Santa Clara River bed, and an end-dump truck to transport it to the processing plant for treatment.

At all the plants in the district, raw material is treated in conventional wet and dry circuits, where it is crushed, washed, classified and stockpiled in appropriate sizes.

Reserves and Resources: Factors considered when determining reserves for this district are:

1. Setbacks range from 0 to 100 feet.
2. Slopes range from 0 to 1:1 (horizontal to vertical ratio).
3. Material density estimates range from .063 tons/ft.³ to 0.069 tons/ ft.³.
4. Quarry and pit depths range from 50 to 300 feet.
5. Waste representing overburden and fine material discarded during processing ranges from 5 to 15 percent.

Taking the above factors into account, it is estimated that more than 10 m.t. of indicated reserves and 340 m.t. of inferred reserves (table 15) existed in the district as of July 1976. The adjusted total reserve is 210 m.t. Inferred resources are 11 m.t. giving an adjusted total resource of 6.6 m.t. Based upon the average rate of production from 1971 to 1975, reserves are adequate to sustain production more than 200 years. If the resources are converted to reserves, it would add 10 years of life to the district.

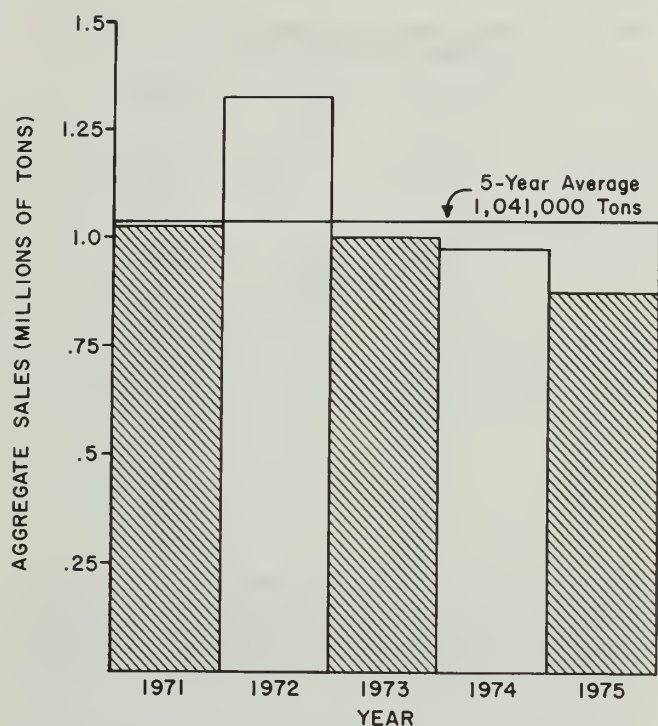


Figure 16. Upper Santa Clara River production district: Aggregate sales from 1971 through 1975.

The volume of gabbro and Mint Canyon conglomerate in bedrock formation in this district is considerable. Much of this could probably be used for aggregate should the need arise. However, detailed sampling and testing will be required in order to determine the quality of this potential large source of aggregate.

TABLE 15. Upper Santa Clara River production district: sales, reserves, and length of life for the district.

1975 Total Sales*	848,000
1971-1975 Average Annual Sales*	1,040,000
Total Reserves*	$+ 10 \text{ m.t. (In)} \times 0.8 = 8.0 \text{ m.t.}$ $+ 340 \text{ m.t. (If)} \times 0.6 = 200 \text{ m.t.}$ adjusted: 210 m.t.
** M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	$+ 11 \text{ m.t. (In)} \times 0.6 = 6.6 \text{ m.t.}$ adjusted: 6.6 m.t.
Estimate Life of District Based on 1975 Adjusted Reserves	$210 \text{ m.t.} \div 1.04 \text{ m.t./yr} = 200 \text{ yrs}$
Estimated Extended Life of District if all Resources are Converted to Reserves	$(210+6.6) \text{ m.t.} \div 1.04 \text{ m.t./yr} = 210 \text{ yrs}$

* Short Tons

** See Reserve and Resource Calculation Factors Section

Land and Water Use: Aggregate mining and processing operations are subject to restrictions set forth by the County of Los Angeles for part of the area, and by the U. S. Forest Service for lands within the Angeles National Forest. Mining operations in the Angeles Forest by P. W. Gillibrand Company are required to stay 10 feet above the level of Pole Creek.

The operations conducted by Curtis Construction Company are in areas zoned Q (Quarry) and M2 (Heavy Industrial) by the county; definitions of these zones include the conditions for mining and processing.

Water used in processing and dust control comes from company-owned wells. Water is circulated through the plant and then discharged into settling ponds where particulate matter settles out. All except what is lost by seepage and evaporation is then sent back to the plant for recycling.

Environmental Considerations: Environmental problems for this district are minimal because it is in a sparsely inhabited area. Production is confined to daylight hours and the plants must control dust and remove particulate matter from waste water discharged from their plants.

No rehabilitation plans exist for the properties in the district after the reserves have been depleted. Should mining of aggregate from the Santa Clara River bed terminate the pits there would soon be refilled with sediment as a result of natural heavy seasonal rainfall and runoff.

Orange-Riverside Counties

Santa Ana Mountains and Coastal Plain production district

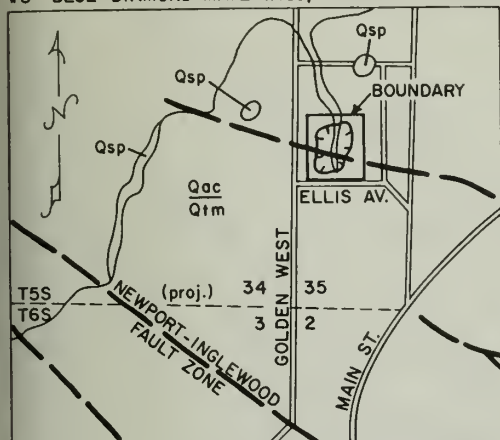
General Data: The Santa Ana Mountains-Coastal Plain production district is centered 25 miles southeast of Los Angeles Civic Center (figures 1, 17, 18, 19, 20, 21). The district includes the Santa Ana River below Prado Dam, the Santa Ana Mountains in Orange County, the Chino Hills in Riverside and Orange Counties, and the Santa Ana coastal plain in northwest Orange County.

As early as 1924, aggregate was mined and processed by Orange County Rock Company, Inc., Santa Ana Rock and Gravel Company, and Yeager Rock Company in Orange County. Numerous small operations have had screening plants along the Santa Ana River (Tucker, W. B., 1925, p. 69-71). In 1976, 15 aggregate plants (table 16) operated in this district.

Geology: Aggregate is mined from 15 locations by eight different companies in the Santa Ana Mountains and Coastal Plain district, from stream channels, floodplains and bedrock. Four stream channels are exploited: Santa Ana River, Santiago Creek, Arroyo Trabuco, and San Juan Creek (figures 19, 20 and 21).

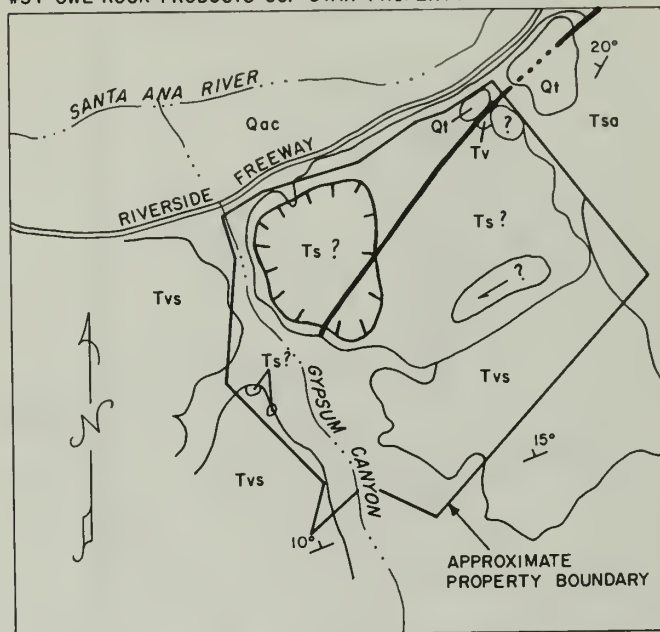
The Santa Ana River, with headwaters east of Redlands, San Bernardino County, is the largest single drainage feature furnishing aggregate in this district. Because of the large area drained by this river, clastic sediments deposited in its channel and the adjacent floodplain shows considerable diversity in composition. Material is mined from the stream channel and floodplain of the river about two miles south of the city of Anaheim by two

#5 BLUE DIAMOND MATERIALS, HUNTINGTON BEACH



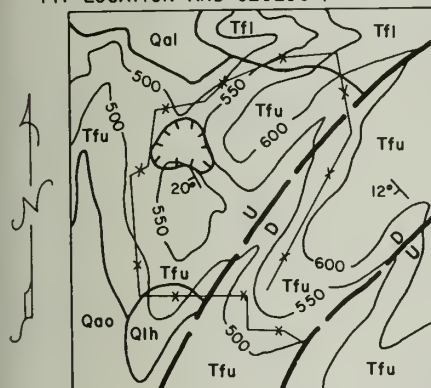
GEOLOGY MODIFIED FROM
MORTON, P.K. AND
MILLER, R.V., 1973

#54 OWL ROCK PRODUCTS CO.-STAR PROPERTY



GEOLOGY MODIFIED FROM
MORTON, P.K. AND
MILLER, R.V., 1973

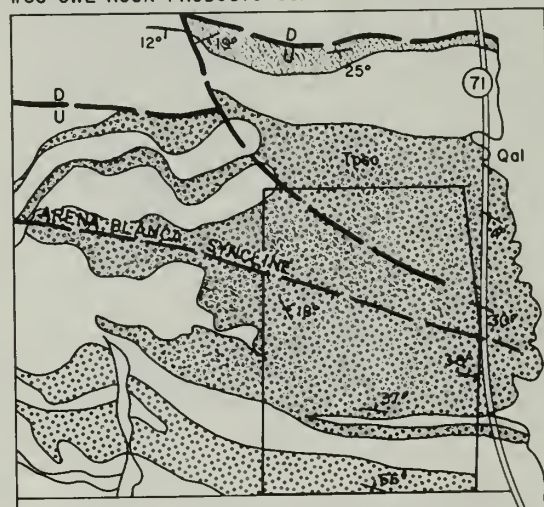
#71 RAKO CONSTRUCTION CO.-YORBA LINDA OPERATION (SKETCH MAP SHOWING PIT LOCATION AND GEOLOGY)



GEOLOGY MODIFIED FROM
DURHAM, D.L. AND
YERKES, R.F., 1964

0 500' 1000'
Contour Interval = 50 Feet

#56 OWL ROCK PRODUCTS CO.-PRADO PROPERTY



GEOLOGY MODIFIED FROM DURHAM, D.L. AND YERKES, R.F., 1964

0 1/2 1 Mile

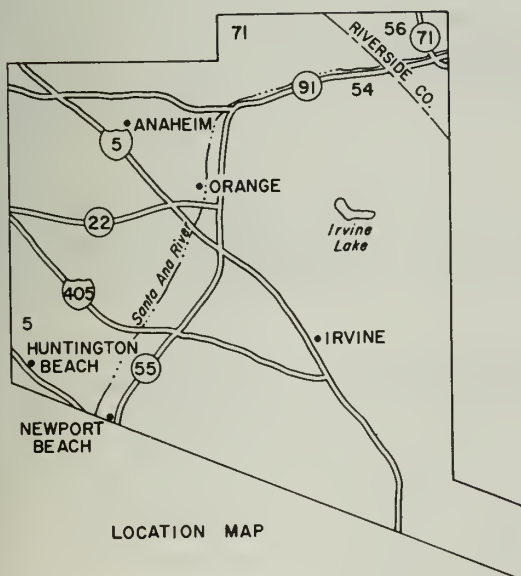
SYMBOLS



EXTRACTION AREA

— APPROXIMATE FAULT TRACE

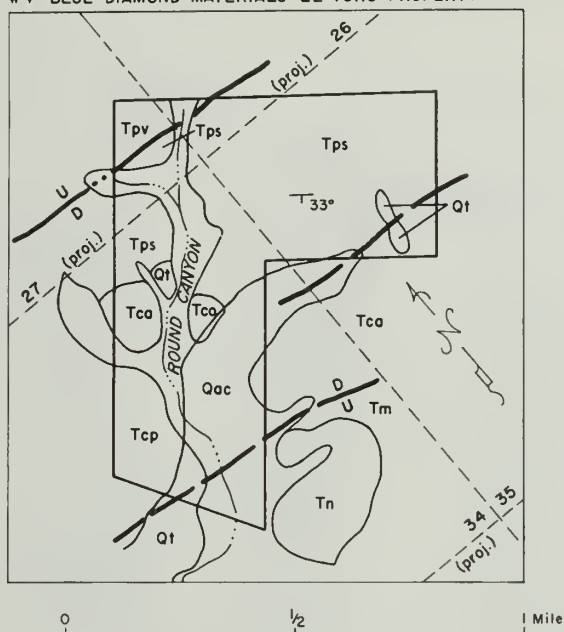
10°/ STRIKE AND DIP



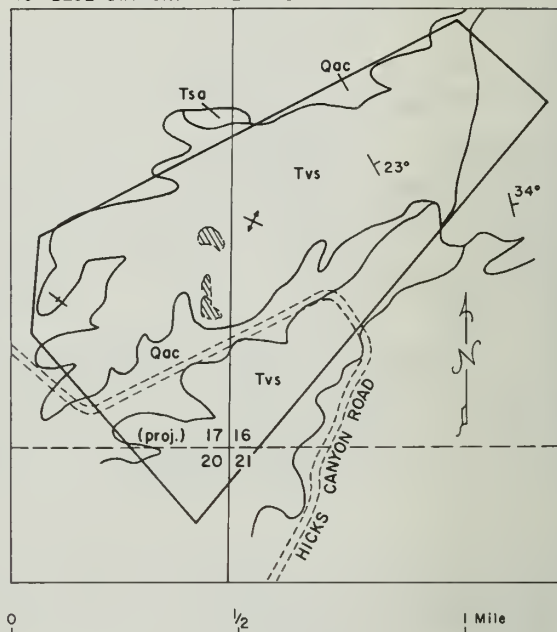
LOCATION MAP

Figure 17. Geologic sketch maps of bedrock deposits in the northern and western Santa Ana Mountain-Coastal Plain district (see Figure 1) (see Figure 18 for explanation).

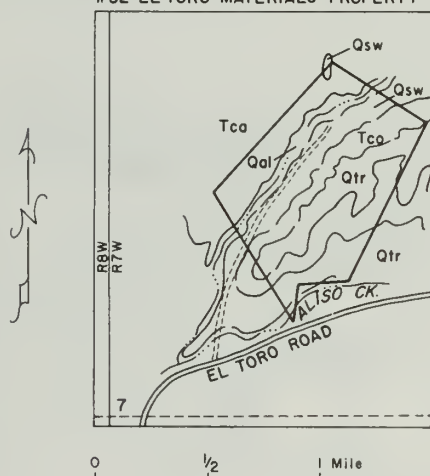
#4 BLUE DIAMOND MATERIALS-EL TORO PROPERTY



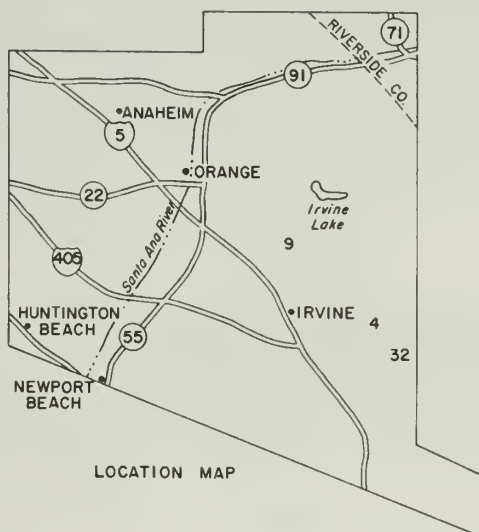
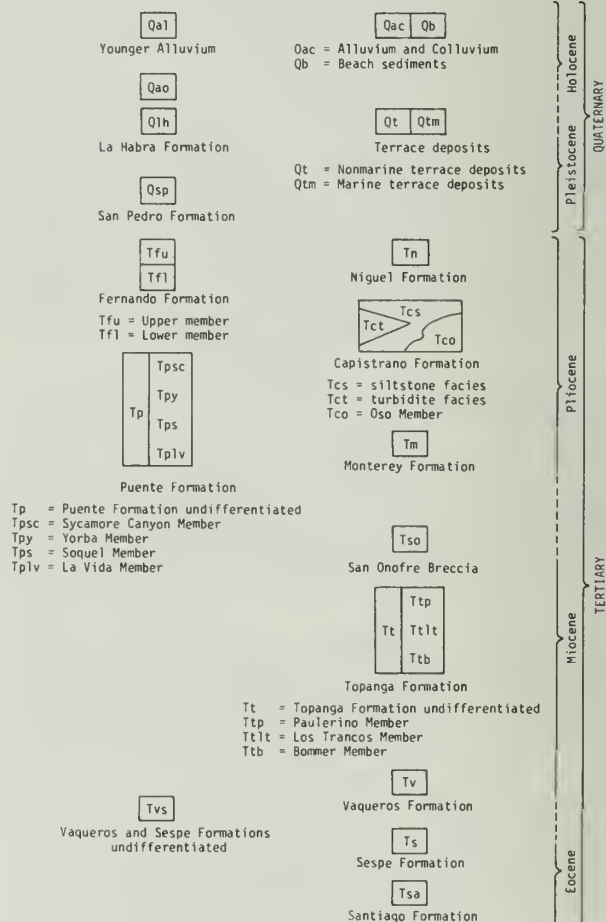
#9 BLUE DIAMOND MATERIALS-JEFFREY ROAD PROPERTY



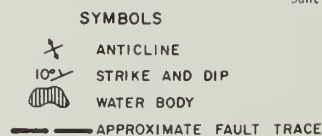
#32 EL TORO MATERIALS PROPERTY



EXPLANATION



LOCATION MAP



GEOLOGY MODIFIED FROM MORTON, P.K. & MILLER, R.V., 1973

Figure 18. Geologic sketch maps of bedrock deposits on the western slope of Santa Ana mountains.

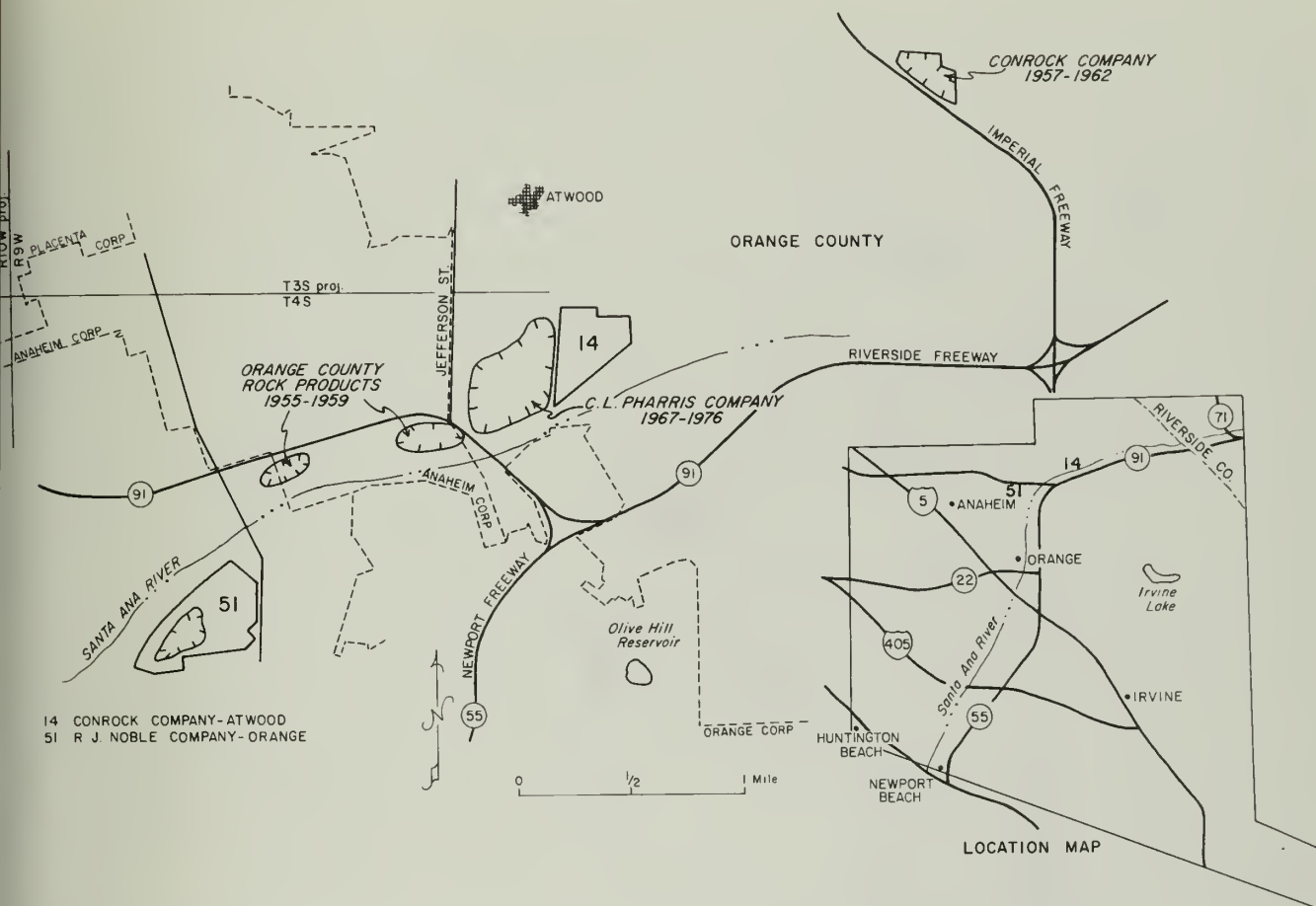


Figure 19. Sketch map of land owned or leased by aggregate mining companies along the Santa Ana River as of July 1976 (see Figure 1).

operators (figure 19). R. J. Noble Company extracts aggregates from a river-channel deposit made up of approximately 50 percent coarse material. Several varieties of granite are present along with subordinate volcanic rocks and sandstone. Aggregate materials extend to at least 180 feet in depth.

About two miles east of the R. J. Noble Company site, floodplain deposits of the Santa Ana River are mined by Conrock Company at its Atwood operation (figure 19). Most of the material mined is composed of feldspar sands, with small amounts of silt and clay, at least 45 feet deep.

Santiago Creek is a southern tributary to the Santa Ana River whose headwaters originate about 20 miles southeast from its mouth. Clastic sediments are transported by the river from the Santa Ana Mountains to the north and from Loma Ridge to the south. About three miles upstream from the juncture of the Santa Ana River and Santiago Creek, the stream channel cuts across an old alluvial fan where detrital material extends to at least 500 feet in depth.

Conrock Company mines and processes aggregate at its Orange operation (figure 20). The aggregate is composed of coarse material containing approximately 50 percent volcanic rocks and about equal amounts of granite, sandstone and shale.

The Blue Diamond Materials' Orange-Hewes operation, is upstream and adjacent to the Conrock's Orange operation (figure 20). The material here is similar to that mined by Conrock except for a modest increase of coarse material. Three miles to the south of this plant and upstream from Irvine Lake, a new operation was being developed in 1976 by Blue Diamond Materials. Aggregate there is similar in composition and size distribution to that mentioned previously. The stream channel ranges from 15 to about 40 feet deep. Upstream and adjacent to Blue Diamond's Irvine Lake operation, aggregate is mined by Azusa Western (figure 20). Approximately 65 percent of this deposit is composed of coarse aggregates, with a composition similar to that found elsewhere along the Santiago Creek channel.

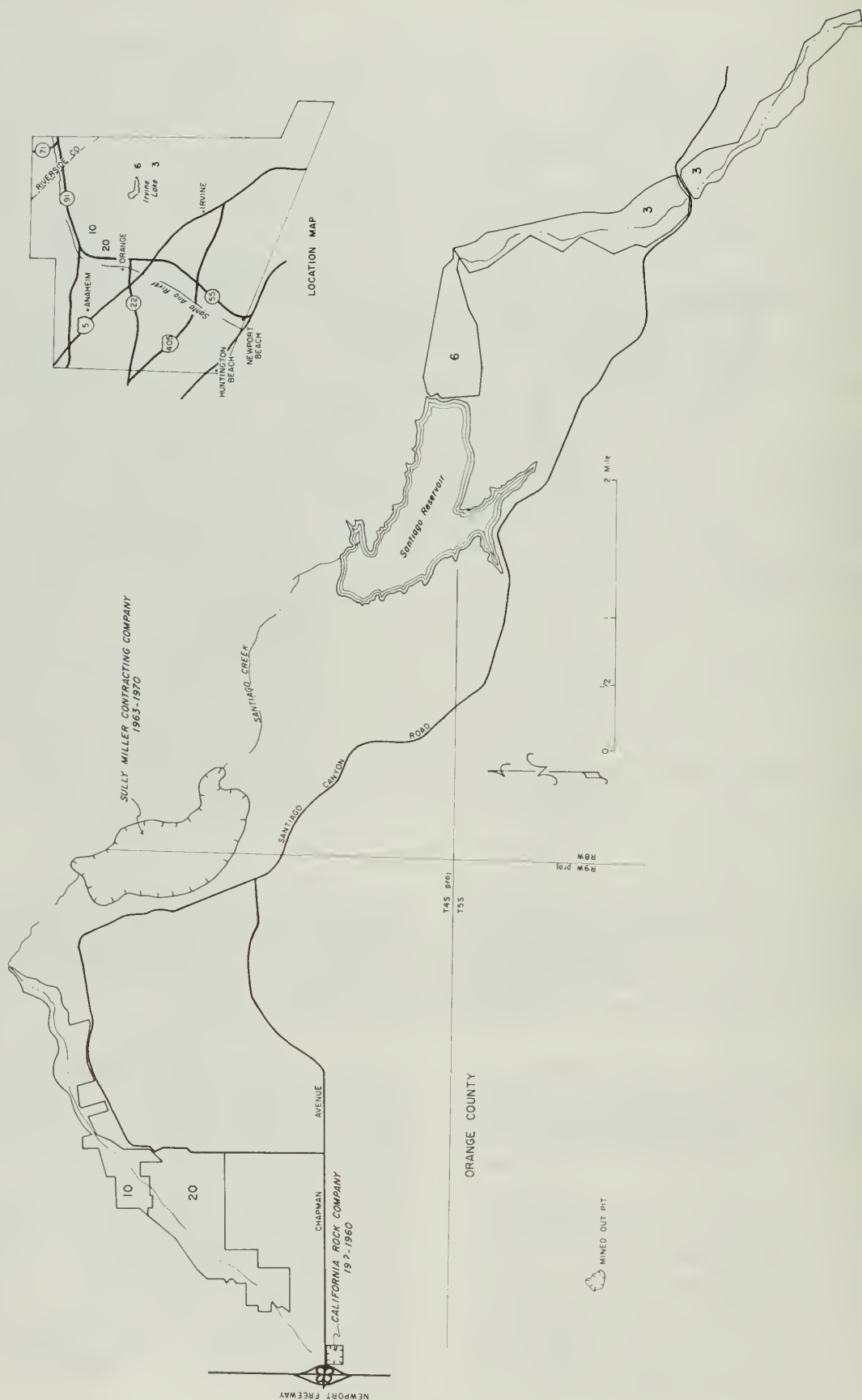


Figure 20. Sketch map of land owned or leased by aggregate companies along the Santiago Creek as of July 1976.



Figure 21. Sketch map of land owned or leased by aggregate companies along Arroyo Trabuco and San Juan Creek as of July 1976 (see Figure 1).

In southwestern Orange County, aggregate is mined where Arroyo Trabuco and San Juan Creek join, a few miles east of San Juan Capistrano (figure 21). Both have their headwaters in the Santa Ana Mountains about 15 miles to the northeast, where elevations in excess of 5,000 feet are attained. Aggregate is mined by Livingston-Graham Incorporated in Arroyo Trabuco, two miles northeast of San Juan Capistrano (figure 21). The Arroyo Trabuco channel is estimated to be 50 to 90 feet deep, based upon drilling and seismic records. Coarse aggregate, composed of metavolcanic rocks, granite, quartz diorite, and minor sedimentary rocks, makes up a little over 50 percent of the deposit; the balance is mostly sand with lesser amounts of silt and clay.

Approximately six miles east of San Juan Capistrano, material is mined from the San Juan Creek channel by

Conrock Company (figure 21). The bedrock contact beneath the deposit has a very irregular configuration and rarely is deeper than 35 feet. About 20 percent of the material contains coarse aggregate, mostly metavolcanic rocks, with subordinate amounts of granite, quartz diorite and minor quantities of sedimentary rocks. The remaining 80 percent of the deposit is sand, with lesser amounts of fine material.

Aggregate is mined from several bedrock deposits in the district. Three of these deposits are along the southwest slope of the Santa Ana Mountains, and the rest are in the northern part of Orange and western Riverside Counties (figures 17 and 18).

Five miles east of Tustin, near the base of the Santa Ana Mountains, Blue Diamond Materials mines aggregate

Table 16. Santa Ana Mountains-Coastal Plain production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
3	Azusa Western	Santiago	Irvine Ranch S111,112 115,116,145-147,149	Stream Channel	50	230	C
4	Blue Diamond Materials	El Toro	Irvine Ranch S152	Bedrock	55	500	A,B,F,
5	Blue Diamond Materials	Huntington Beach	S35 T5S R11W	Bedrock	10	100	A,B
6	Blue Diamond Materials	Irvine Lake	Irvine Ranch S111	Stream Channel	50	500	C,A,B,F
9	Blue Diamond Materials	Jeffrey Road	Irvine Ranch S81,82, 107	Bedrock	40	---	Inactive
10	Blue Diamond Materials	Orange-Hewes	S13,14,22-24 T4S R9W	Floodplain	50	450	C,A,B,F
14	Conrock Company	Atwood	S4 T4S R9W	Floodplain	2	150	C,P
20	Conrock Company	Orange	S28 T4S R9W	Floodplain	50	1000	C,A,B,F,
23	Conrock Company	San Juan	S30 T7S R6W S25,35,36 T7S R7W	Stream Channel	25	450	C,A,B,F
32	El Toro Materials	El Toro	S7 T6S R7W	Bedrock	0	500	F
47	Livingston-Graham, Inc.	San Juan Capistrano	S5,7,3,18,19 T7S R7W	Stream Channel	55	425	C,A,B,F,O
51	R.J. Noble Company	Santa Ana	S7 (proj.) T4S R9W	Floodplain	50	180	A,B
54	Owl Rock Products	Star	Irvine Ranch S28,30	Bedrock	55	1200	C,A,B,F,O
56	Owl Rock Products	Prado	S19 T3S R7W	Bedrock	5	650	C,A,F,P
71	Rako Equipment Co.	Yorba Linda	S16 T3S R9W	Bedrock	20	175	B,F

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)

** See Figure 1

from Eocene Vasquez and Sespe Formations (figure 18) at its Jeffrey Road operation. These formations are conglomerate, conglomeratic sandstone, silty sandstone, and marine and nonmarine siltstone. At the Jeffrey Road pit, these formations are undifferentiated; typical conglomerate beds range from 1.5 to 5 feet thick alternating with thinner beds of sandstone that have been mildly deformed into an east-west trending anticline. A little under 50 percent of the material mined is made up of coarse aggregate, and the balance is sand, silt and clay. A noticeable amount of this material has been extensively altered by chemical weathering.

Three miles southeast of the Jeffrey Road operation, Blue Diamond Materials mines and processes aggregate from its El Toro property located in the Round Canyon area, from the Soquel Member of the Pliocene Puente Formation (figure 18). The strata trends northwest and dips 30 to 35° southwest. The beds are moderately indurated conglomerate, which intertongue with lenses of quartz-sand, silt and minor clay. About 65 percent of the deposit is coarse aggregate, and 20 to 30 percent has been extensively altered by chemical weathering.

The only other bedrock deposit where aggregate is mined on the west slope of the Santa Ana Mountains is

operated by El Toro Materials (figure 18). It is three miles southeast of the Blue Diamond Materials' El Toro operation, and north of El Toro Road. Here aggregate is mined from a marine sandstone: the Oso Member of the Pliocene Capistrano Formation. The material is moderately indurated and composed primarily of sand and silt, containing about 5 percent concretions that are not generally suitable for crushed rock. Much of this is used for fill.

Three of the bedrock deposits are located in the northeastern part of the district and these include Owl Rock Products Company's Star operation in Gypsum Canyon, the Prado operation in Riverside County, and the Yorba Linda operation of the Rako Equipment Company (figure 17).

Conglomerate of the Eocene Sespe Formation is mined by Owl Rock Company at its Star plant, south of the Riverside Freeway, 13 miles east of Anaheim in Gypsum Canyon (figure 17). The deposit has been extensively weathered to a depth of about 100 feet, resulting in development of clay and substantial weakening of portions of the coarse fraction. Below the zone of alteration, material is hard and durable. An estimated 60 percent of the deposit contains coarse aggregate composed of granite, volcanic rocks, feldspathic gneisses, and schists.

At a site about five miles northeast of Corona and about half a mile west of Prado Dam, Owl Rock Products extracts aggregate from the Sycamore Member of the Puente Formation (figure 17). Here the beds are folded into an east plunging syncline, dipping from 40 to 60°. This deposit is extensively weathered near the surface. About 75 percent of the material mined consists of fine material. Approximately 75 percent of this fine material is sand, and the balance is equally divided into silt and clay. The coarse fraction contains several types of granite and minor amounts of chert; the fine fraction is made up of quartz, ferromagnesium silicates and magnetite. Biotite and clay, which occur in the fine fraction, are discarded as waste.

About one and one-half miles northwest of Yorba Linda, the Rako Equipment Company mines aggregate from the Upper Pliocene Fernando Formation (figure 17). The material is pebbly, cross-bedded sandstone. About 20 percent of the deposit is coarse material, with abundant mudstone concretions.

The remaining bedrock deposit mined in the Santa Ana Mountains-Coastal Plain district is about two miles north of Huntington Beach at about 50 feet elevation (figure 17). The deposit occurs beneath a Quaternary marine terrace where a pebbly sandstone of the San Pedro Formation is mined for aggregate. About 10 percent of the deposit is coarse material; about 60 percent of this is granite or dioritic rock, and the balance is gneiss and minor sandstone.

Production and Market Data: The 15 active plants in the Santa Ana Mountains-Coastal Plain district (table 16) averaged 500,000 tons output in 1975, while individual plants produced from 4,000 to over 1.2 m.t. of aggregate in 1975. These plants produced washed concrete sand, plaster sand, gravel, unwashed sand, dust, crushed rock, base and fill. It is estimated that the production was sold and utilized as outlined:

Product Use	Percentage	F.O.B. Price Range (ton)
Concrete aggregate	45%	\$2.00-3.35
Asphalt concrete	20%	\$2.00-3.25
aggregate		
Base material	21%	\$2.00-3.35
Fill	14%	\$1.00-1.50

Aggregate produced in this district is sold in Orange, southeastern Los Angeles, southwestern San Bernardino, western Riverside and northern San Diego counties. It is shipped entirely by trucks owned by aggregate companies or independent contractors.

During the period 1960-1975, inclusive, over 150 m.t. of aggregate were produced in the district (table 17). For the five-year period 1971-1975 production averaged 10.2 m.t. per year (figure 22).

Table 17. Santa Ana Mountains-Coastal Plain production district: Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	6,356,518
1961	6,842,583
1962	7,961,970
1963	10,009,000
1964	7,893,771
1965	8,273,962
1966	10,526,422
1967	9,535,357
1968	11,443,917
1969	10,490,606
1970	10,017,776
1971	10,156,130
1972	11,801,795
1973	12,437,112
1974	9,478,931
1975	7,020,986
TOTAL	150,246,836

Extraction and Processing: The methods of extraction used in this district are as diverse as the geological settings of the deposits. In 1976, one of the 15 aggregate plants in this district was shut down temporarily, and another was in preparation to begin operation; the remaining 13 plants were active.

Highly indurated and cemented units, such as portions of the Sespe Formation, require drilling and blasting to prepare deposits for removal. At the Star Plant a contract blasting firm drills on benches cut into the side of the hill. Fifty pounds of ammonium nitrate is packed in each hole and detonated to fragment the cemented conglomerate and make it available for loading and delivery to the processing plant.

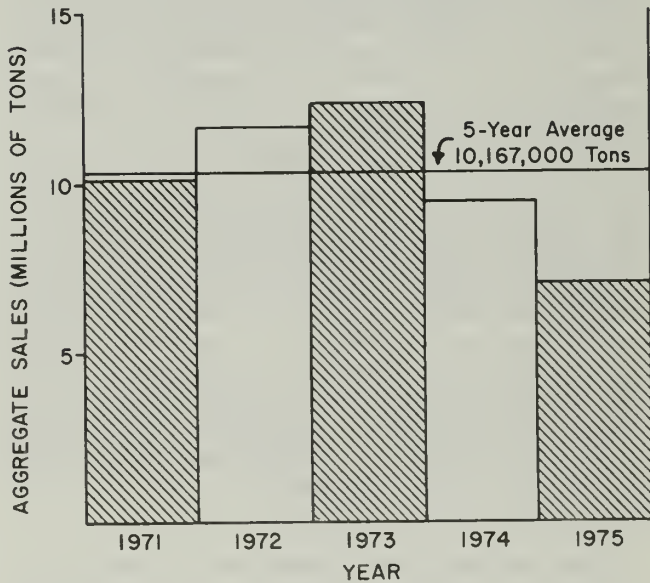


Figure 22. Santa Ana Mountains-Coastal Plain production district: Aggregate sales from 1971 through 1975.

At other bedrock operations in the district the raw material is moderately indurated sandstone and conglomerate, which is excavated by bulldozers and moved to conveyor hoppers. This is the practice at the El Toro Materials, Blue and Star plants, and at the R. J. Noble Company and the Rako Equipment Company plants. In addition, at the Owl Rock Products' Star plant, a front loader dumps raw material into a conveyor-belt hopper, and at the Rako Equipment Company property in Yorba Linda a front loader feeds a portable screening plant.

The Blue Diamond Materials plant at Huntington Beach uses a dragline to excavate pebbly sand from below the water table. A two and one-half cubic yard bucket is hung on a cable that spans the open pit and lake. The cable connects with a crane used as a "deadman" at one end, and with a center pole at the other end, adjacent to the cable house. Pit material is dumped at the water edge by the bucket and is then picked up by a crane fitted with a clamshell and moved to a stockpile adjacent to a loading hopper. A bulldozer pushes the material into a hopper for transport by conveyor belt to the plant.

In the district's stream channel and floodplain deposits, where the material is lightly indurated, front loaders or power shovels are used for extraction. At Conrock Company's Orange plant, a bank drag loosens aggregate from the wall of a 150 feet deep pit, and a shovel then lifts it from the pit floor and dumps it into a hopper conveyor belt. At Conrock Company's Atwood plant, a power shovel-conveyor belt system is used without a bank drag because the pit is not deep enough to require one.

Euclid bottom-dump trucks are loaded by power shovel at Livingston Graham's San Juan Capistrano operation, and at Blue Diamond Material's Orange-Hewes plant. It is anticipated that this method of mining will be used at Blue Diamond's new Irvine Lake property, along with a dragline to excavate below water level. Front loaders extract material and load into Euclid bottom-dump trucks at Azusa Western's Santiago plant and at Conrock's San Juan plant. Trucks are also used at Blue Diamond Materials' Orange-Hewes and El Toro plants, at Azusa Western's Santiago plant, at Conrock's San Juan plant, and at Livingston-Graham's San Juan Capistrano plant. Haulage distances range from 0.5 to over 3 miles. Belt conveyors carry material from distances ranging from 15 to over 3,000 feet. These conveyors are used by Conrock's Orange and Atwood plants, by Blue Diamond Materials' Huntington Beach and Jeffrey Road plants, by Owl Rock Products' Star plant and by the R.J. Noble Company plant and the El Toro Materials plant.

Conventional equipment is used at the processing plants to crush, screen and wash aggregate. Thickeners are occasionally used to remove excess water at plants that process aggregate with a substantial amount of waste.

Reserves and Resources: Constraints that affect mining practice and quantities of mineable materials in this district include:

1. Setbacks from property lines range up to 50 feet in width.
2. Approved grading plans, or pit slopes are 1-1/2:1 (horizontal to vertical ratio).
3. Maximum pit depths are 150 feet. Depths of some pits are due less to technological constraints than to changes in material composition or economic factors.
4. The position of the water table, insofar as it affects the depth of mining, is a constraining factor.
5. The ratio of overburden to aggregate may determine the limits of mineable material. This factor usually applies to hillside deposits, but occasionally it is significant in stream channel deposits.
6. Geologic factors, areal distribution, thickness and dip of aggregate beds, or the configuration of a stream channel may limit reserves.
7. Waste representing overburden and fine material discarded during processing ranges from 0 to 40 percent.
8. Estimates of the tonnage factor, based upon operator experience, are .058 tons per cubic foot for stream channel deposit, .065 tons per cubic foot for floodplain deposits, .074 to .078 tons per cubic foot for bedrock deposits.

Taking into account the above factors, it is estimated that as of July 1976 there were more than 2.3 m.t. of measured reserves, 58 m.t. of indicated reserves, and 26 m.t. of inferred reserves in the district (table 18). The adjusted total reserve was 65 m.t. of aggregate. There were approximately 89 m.t. of indicated resources; this figure renders an adjusted total of approximately 71 m.t. Based upon the average annual rate of production from 1971 to 1975, reserves are sufficient to sustain six years of production. If all the resources are converted to reserves, it would add approximately seven more years of life to the district.

TABLE 18. Santa Ana Mountains-Coastal Plain production district: sales, reserves, and length of life for the district.

1975 Total Sales*	7,847,000
1971-1975 Average Annual Sales*	10,170,000
Total Reserves*	2.3 m.t. (M) x 1.0 = 2.3 m.t. +58 m.t. (In) x 0.8 = 47 26 m.t. (If) x 0.6 = 16 adjusted: 65 m.t.
** M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	+89 m.t. (In) x 0.8 = 71 m.t. adjusted: 71 m.t.
Estimate Life of District Based on 1975 Adjusted Reserves	65 m.t. ÷ 10.2 m.t./yr = 6 yrs
Estimated Extended Life of District if all Resources are Converted to Reserves	(65+71) m.t. ÷ 10.2 m.t./yr = 13 yrs

* Short Tons

** See Reserve and Resource Calculation Factors Section

Land and Water Use: Several of the operations in Orange County are in areas zoned "A-1 General Agriculture," but operate under Use Permits or Use Variances. These permits specify conditions the operator must meet in order to mine and process aggregate. Setbacks and finished pit slopes often are not required, especially for the older operations. Hours of production as well as dust control and public safety measures (fencing, signs, etc.) are usually specified. The remaining operations in Orange County are on land zoned "SG - Sand and Gravel and Mineral Extraction District," and those in Riverside County are zoned "MRA - Mineral Resources and Related Manufacturing." Some cities in Orange County have established ordinances similar to the county's "SG" zone, or have contracted with Orange County for zoning regulations specifying that aggregate pits can excavate to a maximum depth of 150 feet, and that they maintain maximum slopes of 1-1 1/2:1 and minimum setbacks of 50 feet from property lines. The "MRA" zone in Riverside County requires a maximum slope of 1:1 and setbacks of 50 feet, but it places no limitation on the depth of mining.

Orange County has enacted a "Sand, Gravel and Mineral Extraction Code" applicable to all active aggregate operations in unincorporated areas of the county. This Code is a safety ordinance requiring the operator to take various public safety measures. An annual operation permit is granted for each property under the Code's jurisdiction.

Each month, 15 operations in this district use approximately 565 acre-feet of water for washing aggregate and maintaining dust control. Much of this comes from company-owned wells on the properties. After passing through the plants, waste water carrying particulate matter is commonly piped to settling basins where the suspended material settles. Clarified water is piped back to the plants for reuse or allowed to percolate back into the ground.

Environmental Considerations: The 15 aggregate properties contain approximately 955 acres of pits and quarries averaging about 64 acres per property. This total does not include pits remaining from depleted operations within the district, or those reclaimed by landfill or in use as spreading basins or lakes.

The Warner Spreading Basin was reclaimed from the C. L. Pharris Company pit adjacent to Conrock Company's Atwood facility. During the 1960's, the southern portion of the reservoir at Villa Park Dam was excavated by Sully-Miller Construction Company. The California Rock Company's former pit along Santiago Creek at Chapman is now Yorba Park. A small aggregate pit located on the west side of the Santa Ana River between Lincoln Avenue and the former Burris sand pit has been used as a site for sanitary landfill.

When the various bedrock deposits are finally depleted of their reserves, they are to be graded to eliminate hazard-

ous slopes. In most cases, overburden removed during mining will be used to cover the pit slopes. The Blue Diamond Material's Huntington Beach property will be sold to the City of Huntington Beach for development as an addition to Central Park. The pit, which contains a permanent lake, will be graded as necessary for public safety.

The "Buchheim-Hurwitz" pit, located south of Santiago Creek at Loma Street and Santiago Canyon Road, has been considered for use as a test site for disposal of Class II solid waste. The pit walls apparently would be sealed with several feet of clay or by a plastic liner and then backfilled with Class II waste. However, the project has not been implemented (Jack Burger, of the Greenbelt Commission for Santa Ana River and Santiago Creek, personal communication, September 27, 1976; Evans, 1973, p. 271).

The Blue Diamond Material's Irvine Lake property and the adjacent Azusa Western property in Santiago Creek have formal excavation and reclamation plans that have been approved by the Orange County Planning Commission. Specific channel contours are delineated, and trees and bushes are being planted as a beautification measure. A private haul road has been built from Santiago Canyon Road south to Jeffrey Road. All aggregate trucks for these two plants will be routed over this private road.

The properties along the Santa Ana River and lower Santiago Creek are being considered for water spreading basins or flood control facilities. No definite plans were available in 1976.

Portions of Livingston-Graham Inc.'s San Juan Capistrano property have been considered as a site for construction of a flood control dam and reservoir. No definite plans are available at present.

Riverside County

Temescal Wash production district

General Data: This district is in Riverside County located approximately 45 miles southeast of Los Angeles Civic Center (figures 1 and 23). Temescal Wash extends northwest from Lake Elsinore to Corona, a distance of approximately 20 miles.

A small sand and gravel plant was erected in 1937, two miles southeast of Corona. Prior to 1942 Custer and Waterbury operated a plant one mile east of Corona at the northeast end of Temescal Wash (Gray, 1961, p. 119). In 1942, this operation was taken over by Transit Mixed Concrete Company. Corona Rock Company has operated in the district at least since 1957, and Elsinore Ready Mix Company has been in production continuously since 1958. In 1967, seven plants were in operation and another was preparing for production in the district (table 19).

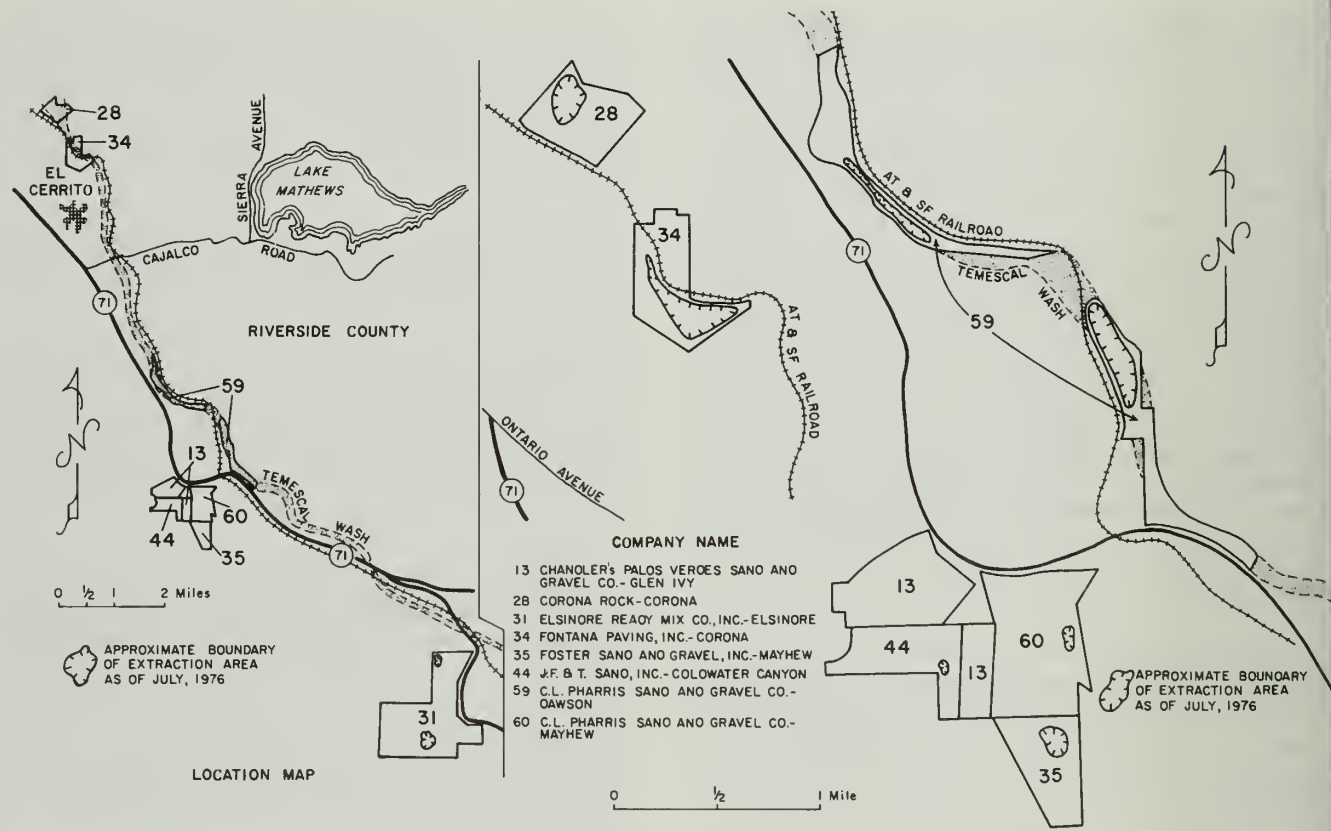


Figure 23. Temescal Wash production district (see Figure 1): Sketch map showing land owned or leased by aggregate companies as of July 1976.

Table 19. Temescal Wash production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
13	Chandler's Palos Verdes Sand and Gravel Co.***	Glen Ivy	S2,3,11 T5S R6W	Alluvial Fan	65	500	C,B,F
28	Corona Rock	Corona	S32 T3S R6W	Stream Channel -Floodplain	25	4 00	C,A,B,F,P
31	Elsinore Ready Mix Company, Inc.	Elsinore	S27,31,33,34 T5S R5W	Alluvial Fan	25	150	C,A
34	Fontana Paving, Inc.	Corona	S4,5 T4S R6W	Stream Channel -Floodplain	35	200	A
35	Foster Sand & Gravel, Inc.	Mayhew	S11 T5S R6W	Alluvial Fan	10	125	C
44	J.F. & T Sand, Inc.	Coldwater Canyon	S10,11 T5S R6W	Alluvial Fan	25	60	C,F
59	C.L. Pharris Sand and Gravel Company	Dawson	S27,34,35 T4S R6W S1,2 T5S R6W	Stream Channel	35	150	A,B
60	C.L. Pharris Sand and Gravel Company	Mayhew	S2,11 T5S R6W	Alluvial Fan	35	50	C,A,P

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)
** See Figure 1
*** Preparing for production

Geology: Temescal Wash is bounded on the southwest by the Santa Ana Mountains where elevations locally exceed 5,600 feet. It is bordered to the northeast by an east-west trending range the highest point of which is Estelle Mountain (elevation 2,767 feet). A trellis drainage pattern has developed in the district, reflecting structural control of drainage developed along zones related to the Elsinore and Chino faults.

The deposits in the district are composed of alluvial materials originating from the adjacent Santa Ana Mountains and the Estelle Mountain area. Accumulations of this material occur in coalescing alluvial fans east of the Santa Ana Mountains and in the Temescal Creek channel and its associated floodplain. The fans merge into Temescal Creek channel and its associated floodplain. The fans merging into Temescal Creek have a combined gradient of about 150 feet per mile, and the creek below has a gradient of 40 feet per mile. The depth of commercially acceptable sand and gravel has not been established. A single drill hole shows 600 feet of alluvium, but no test data is available to indicate its commercial acceptability.

The coarse fraction of the deposits in the district ranges from 10 to about 65 percent. It is composed of several varieties of granitic rock together with assorted mafic and intermediate types of volcanic rock.

Production and Market Data: The eight active aggregate plants in this district are listed on Table 19. Between 1960 and 1975 aggregate sales totaled 8.9 m.t. (table 20). For the period 1971 to 1975, average annual sales were 1.3 m.t. (figure 24). Sales for 1975 totaled 2.0 m.t.; the utilization of these sales is estimated as follows:

Product	Percentage	F.O.B. Price Range (ton)
Concrete aggregate	38.3%	\$1.00-\$2.70
Asphalt concrete aggregate	38.0%	\$1.00-\$2.30
Base material	10.8%	\$1.00-\$1.85
Fill material	2.2%	\$1.00-\$1.65
Other	10.7%	

Aggregate is marketed in western Riverside, southwestern San Bernardino, southeast Los Angeles and north central Orange counties. Transportation is entirely by trucks owned either by the aggregate producing companies or by individual contractors.

Extraction and Processing: Material is mined in this district from pits that range from 2 to 16 acres in size and total 45 acres. Their depths range from 10 to over 70 feet. Front loaders and bulldozers extract raw material from open pits, except at one of the deeper pits where a bank drag is used. Aggregate is transported from the pits to the processing plants with front loaders, conveyor belts, or trucks. If the distance is within a few hundred feet of the

Table 20. Temescal Wash production district: Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	169,160
1961	None recorded
1962	None recorded
1963	119,000
1964	358,000
1965	368,000
1966	469,000
1967	232,000
1968	268,000
1969	252,719
1970	387,961
1971	301,829
1972	856,421
1973	1,481,448
1974	1,699,807
1975	1,980,173
TOTAL	8,943,518

plant, front-end loaders and conveyors are used for haulage. For longer hauls, end or bottom-dump trucks are used.

All material is processed in a conventional wet and dry circuit process, where the material is subjected to crushing, washing, and screening.

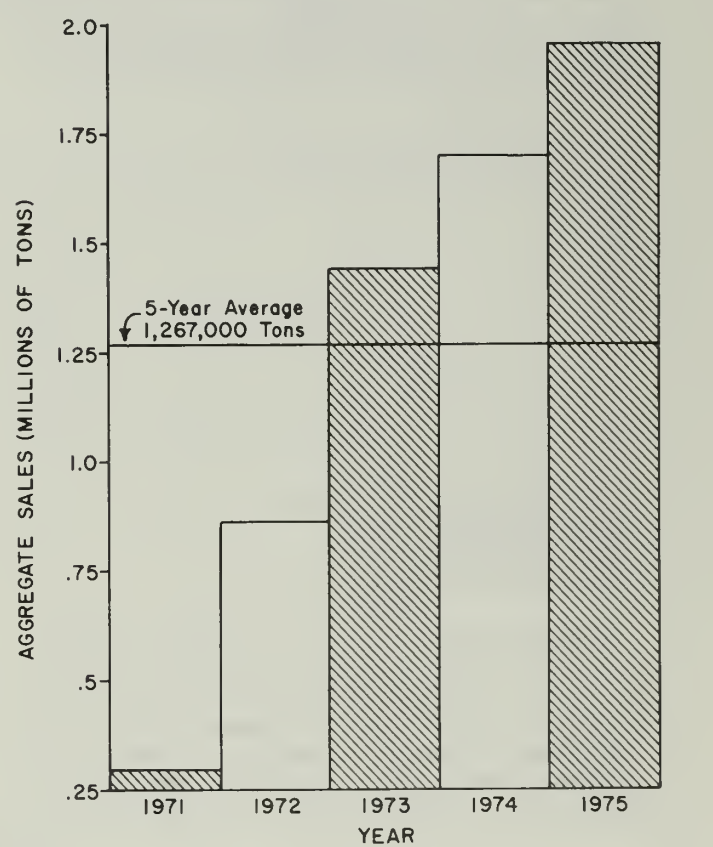


Figure 24. Temescal Wash production district: Aggregate sales from 1971 through 1975.

Reserves and Resources: Technological and governmental constraints that affect reserve and resource calculations for this district include:

1. Minimum setbacks from property lines range from 20 to 250 feet.
2. Limits to mining depth are stipulated on the use permits.
3. Pit slopes are 1:1 (horizontal to vertical ratio).
4. A 10 foot wide bench is stipulated for every 50 feet of depth in same pits.
5. The density of bank run material is estimated to range .063 to .065 tons per cubic foot.
6. Waste consisting of overburden and fine material discarded during processing ranges 5 to 12 percent.

Taking into account the above factors, it was estimated that in 1976 more than 83 m.t. of indicated and 140 m.t. of inferred reserves were present within lands owned or leased by the active companies (table 21). Adjusted total reserves amount to 150 m.t. Indicated resources are 70 m.t. and the inferred resources are 62 m.t. The adjusted total resources are more than 93 m.t. Based upon the average rate of production from 1971 to 1975, sufficient reserves exist to sustain 120 years of production. If all resources were converted to reserves, approximately 70 years of productive life would be added to the district.

TABLE 21. Temescal Wash production district: sales, reserves, and length of life for the district.

1975 Total Sales*	1,980,000
1971-1975 Average Annual Sales*	1,270,000
Total Reserves*	$\begin{matrix} 83 \text{ m.t. (In)} \times 0.8 = 66 \text{ m.t.} \\ + 140 \text{ m.t. (If)} \times 0.6 = 84 \\ \text{adjusted: } 150 \text{ m.t.} \end{matrix}$
** M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	$\begin{matrix} 70 \text{ m.t. (In)} \times 0.8 = 56 \text{ m.t.} \\ + 62 \text{ m.t. (If)} \times 0.6 = 37 \\ \text{adjusted: } 93 \text{ m.t.} \end{matrix}$
Estimate Life of District Based on 1975 Adjusted Reserves	$150 \text{ m.t.} \div 1.27 \text{ m.t./yr} = 120 \text{ yrs}$
Estimated Extended Life of District if all Resources are Converted to Reserves	$(150+93) \text{ m.t.} \div 1.27 \text{ m.t./yr} = 190 \text{ yrs}$

* Short Tons

** See Reserve and Resource Calculation Factors Section

Adequate subsurface data is not available to make a detailed resource determination for the district. However, development of the alluvial fans and wash suggest that a much larger potential resource of aggregate material exists in the district outside the reported acreage controlled by aggregate producing firms. Agricultural use of the land precludes the possibility of developing much of this.

Land and Water Use: The eight aggregate properties are zoned "MRA" - Mineral Resource zone or "M-2-10" by

the County of Riverside. In these zones, regulations specify requirements regarding mining practice, air quality and water discharge. In 1976, one of the plants was preparing for production, another was not washing aggregate while the remaining six plants were using approximately 60 acre-feet of water per month, of which 65 to 100 percent was being recycled from settling basins; tailings were dredged and stockpiled on the properties.

Environmental Considerations: Environmental problems are less pronounced in this district than in some of the others due to its sparse population. However, measures such as spraying roads for dust control and enclosing the property with fences posted with warning signs are followed. Extraction areas are set back 20 feet from property lines, and maximum slopes do not exceed a ratio of 1:1 (horizontal to vertical ratio).

San Bernardino County

Lytle Creek Fan - Upper Santa Ana River production district

General Data: The Lytle Creek Fan-Upper Santa Ana River production district is in southwest San Bernardino County, 40 miles east of Los Angeles Civic Center (figures 1, 25, 26, 27, 28). The District includes the Lytle Creek fan, the Cajon Creek fan, and the Upper Santa Ana River above Riverside. California Division of Mines and Geology records show that production of aggregate in San Bernardino County commenced prior to 1900 (Cloudman and others, 1915, p. 782). Most operations in this part of the county have been located on the Lytle Creek fan.

Geology: This district is situated in an area of coalescing alluvial fans and stream channel deposits, located in the Upper Santa Ana Valley. The alluvial deposits extend over a triangular area of approximately 120 square miles. The depth of the alluvium ranges 100 to more than 1,000 feet, and is controlled by numerous fault-bounded blocks that underlie the valley floor (Fife and others, in press). Elevations range from 1,000 to a maximum of 2,000 feet at the heads of the alluvial fans. Local relief is low, with a maximum difference of approximately 25 feet.

Pit material is composed of light brown to gray, slightly indurated, poorly sorted Holocene-age material. The coarse material ranges from approximately 65 percent of the gross volume at the mouth of Lytle Creek, to a low of approximately 30 percent near the Santa Ana River at Colton. Rock types which make up the deposits include several different species of granite and feldspathic gneisses with subordinate biotite schists and mafic rocks.

Production and Market Data: In 1975, nine plants were active in this district (table 22). Eight of these extract aggregate from alluvial fans or stream channel deposits, and one plant produces base, fill, ballast and asphalt concrete aggregate from steel mill slag.

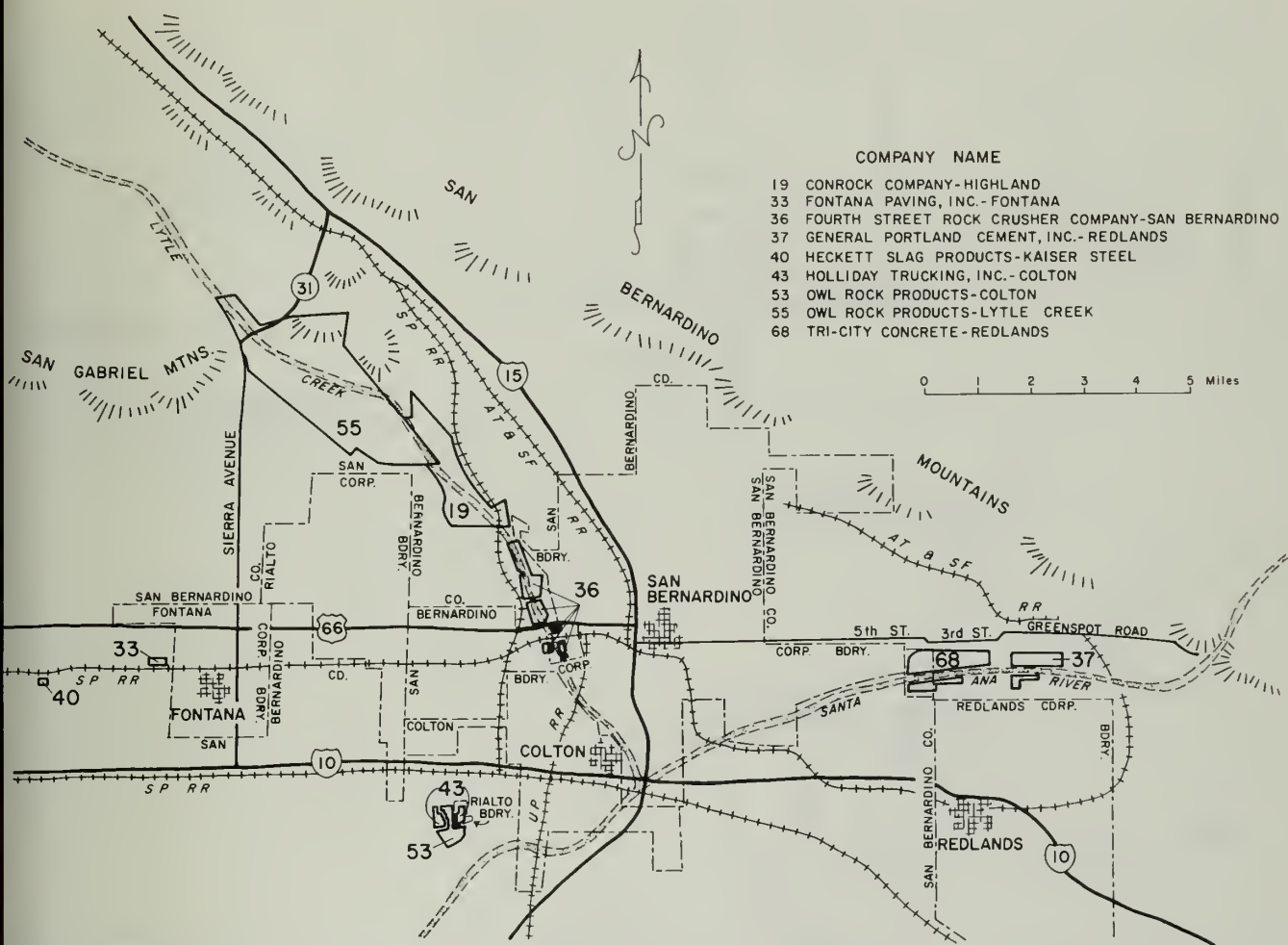


Figure 25. Lytle Creek fan-Upper Santa Ana River production district (see Figure 1): Sketch map showing land owned or leased by aggregate companies as of July 1976.

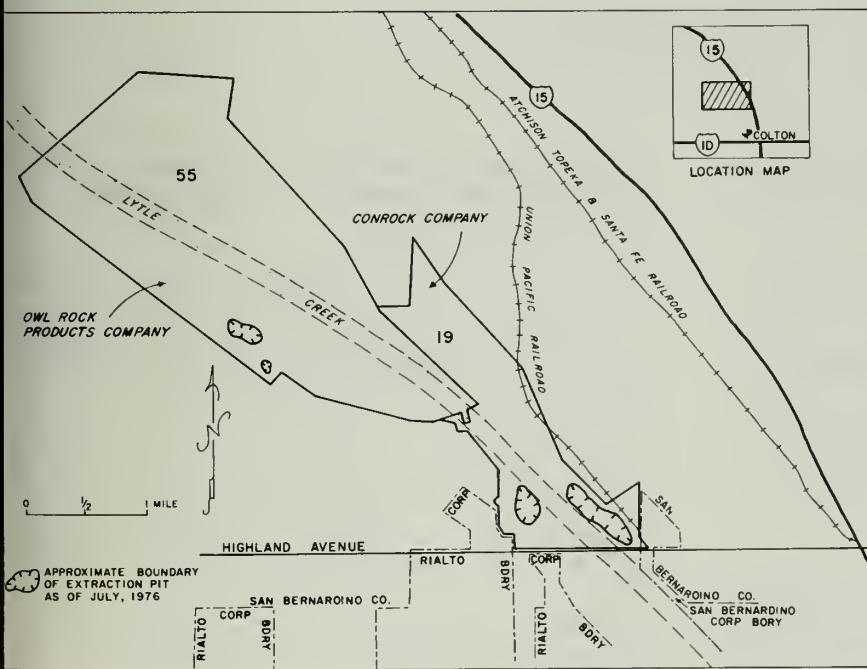


Figure 26. Sketch map showing land owned or leased by aggregate companies in the northern part of the Lytle Creek fan-Upper Santa Ana River production district.

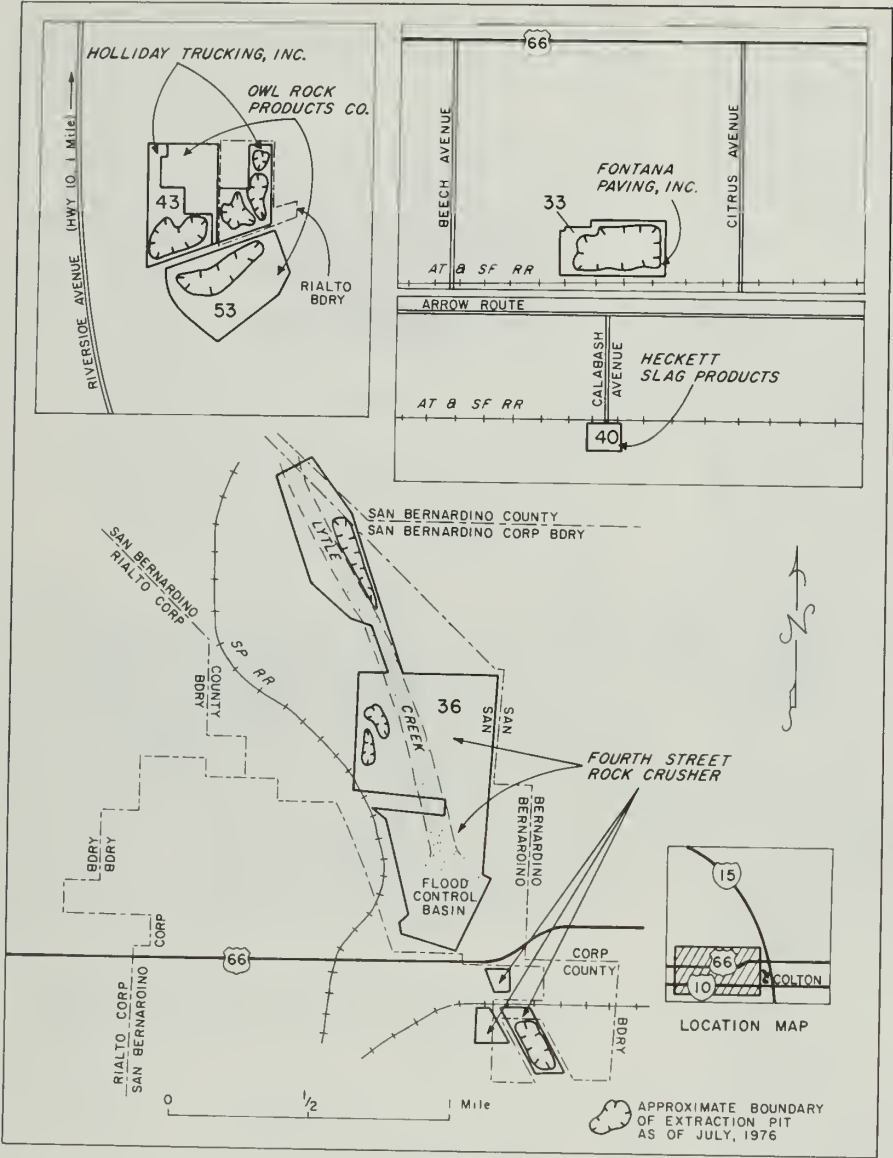


Figure 27. Sketch map showing land owned or leased by aggregate companies in the western part of the Lytle Creek fan—Upper Santa Ana River production district as of July 1976.

Production for 1975 totaled over 3.0 m.t. Estimates of how this was utilized and sold are as follows:

Product Use	Percentage	F.O.B. Price Range (ton)
Concrete aggregate	35.8%	\$1.29–\$2.70
Asphalt concrete	21.1%	\$1.29–\$3.50
Base	18.8%	\$1.29–3.00
Fill	16.5%	\$1.29–\$2.70
Other	7.8%	

Products are marketed primarily in the San Bernardino–Riverside metropolitan areas, with lesser amounts sold in Victorville, east Los Angeles County, Orange, Imperial

and San Diego counties. All of the aggregate is hauled by trucks owned and operated by the aggregate companies or independent contractors.

From 1960 to 1975, total production for this district was over 50.6 m.t. (table 23). Average annual production 1971 to 1975 exceeded 3.5 m.t. (figure 29). Production from this district represents about 7.2% of the total for the entire study area for the period 1960 to 1975.

Extraction and Processing: The existing pits in the district are 45 to 80 feet deep. They extend over areas 1.5 to 77 acres. Power shovels are commonly used for mining aggregate. However, three operators use front loaders, and one uses a Caterpillar 633 self-loading scraper.

Material is trucked as far as 1.5 miles from the pit to the processing plant, where it is crushed, screened and

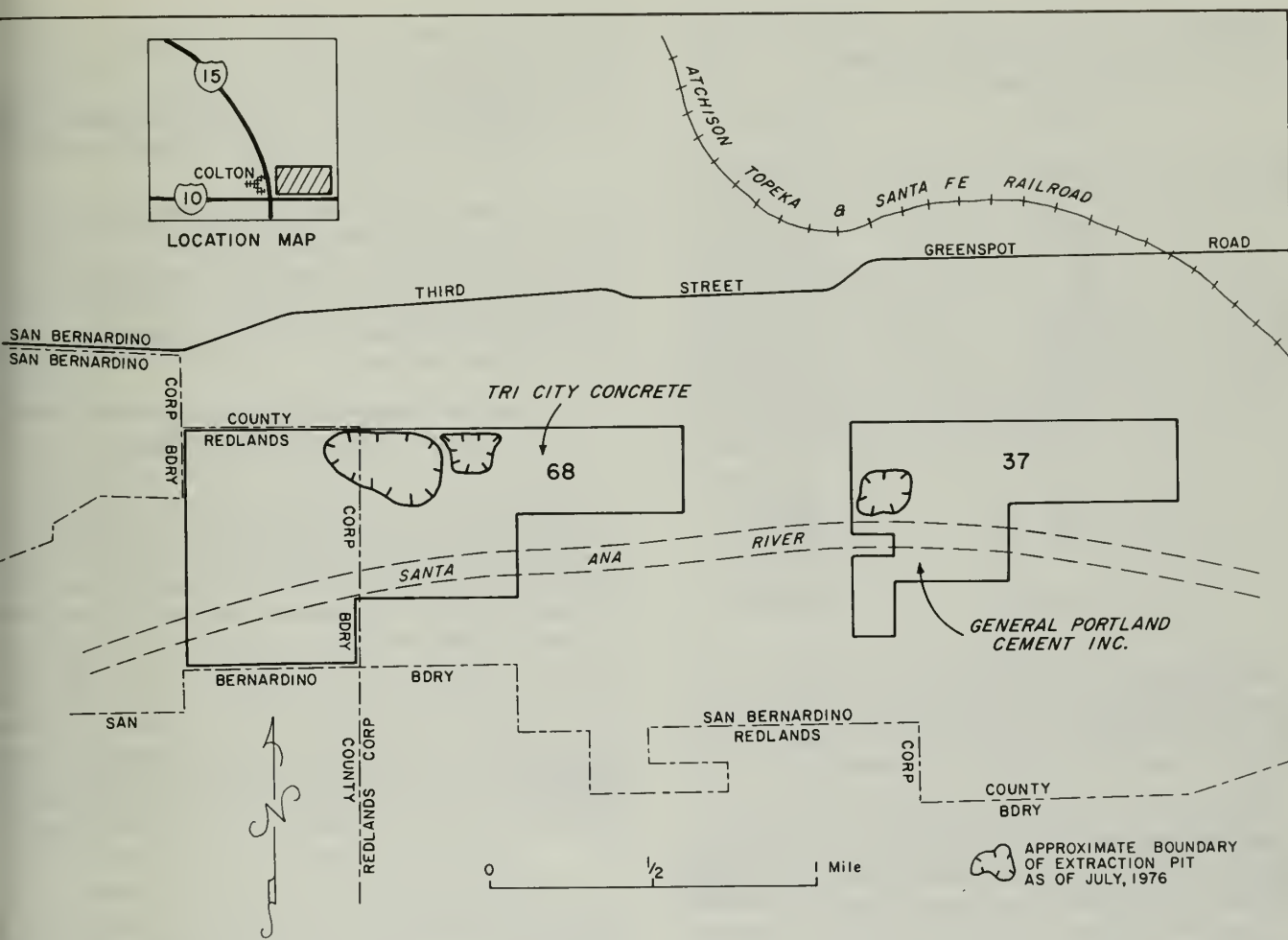


Figure 28. Sketch map showing land or leased by aggregate companies in the eastern part of the Lytle Creek fan—Upper Santa Ana River production district as of July 1976.

Table 22. Lytle Creek fan—Upper Santa Ana River production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATLD PLANT CAPACITY (tons per hour)	PRODUCTS*
68	Tri-City Concrete	Redlands	S9,10 T1S R3W	Stream Channel	50-60	475	C,A,B,F,P
37	General Portland Cement Company	Redlands	S11 T1S R3W	Stream Channel	45-50	---	No Plant
55	Owl Rock Products	Lytle Creek	S6,7,8,9,10,15,16,17,21,22,23 (proj.) T1N R5W	Alluvial Fan	60-65	650	C,A,B,F
19	Conrock Company	Highland	S14,23,24,25 T1N R5W	Alluvial Fan	35-40	650	C,A,B,F
36	Fourth Street Rock Crusher Company	Fourth Street	S31 T1N R4W S6,8 T1S R4W	Alluvial Fan	30-35	250	C
33	Owl Rock Products	Colton	S25,26,35,36 T1S R5W	Alluvial Fan	25-30	300	C,A
43	Holliday Trucking, Inc.	Colton	S25,26 T1S R5W	Alluvial Fan	25-30	225	C,F,P
33	Fontana Paving, Inc.	Fontana	T1S R6W	Alluvial Fan	50-55	200	A
40	Heckett Slag Products	Kaiser Steel	S10 T1S R6W	Steel Slag	----	600	C,A,B,O

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)

** See Figure 1

Table 23. Lytle Creek fan-Upper Santa Ana River production district: Aggregate sales from 1900 through 1975.

YEAR	TONS
1960	1,503,278
1961	2,647,948
1962	3,465,215
1963	1,374,736
1964	3,681,000
1965	3,644,360
1966	3,732,081
1967	2,970,020
1968	3,787,538
1969	2,991,082
1970	3,041,766
1971	3,858,189
1972	3,697,365
1973	3,859,575
1974	3,334,524
1975	3,064,641
TOTAL	50,653,318

stockpiled. Waste, which varies from 2 to 20 percent of the gross volume, depends on the type of rock, the degree of weathering, the distance of transport from the source area, and the types of products for which the aggregate is to be used.

Heckett Slag Products manufactures an assortment of aggregate products (riprap, ballast, concrete aggregate, roofing aggregate, etc.) from steel mill slag at Kaiser Steel Corporation, Fontana. The slag is crushed and screened to various sizes.

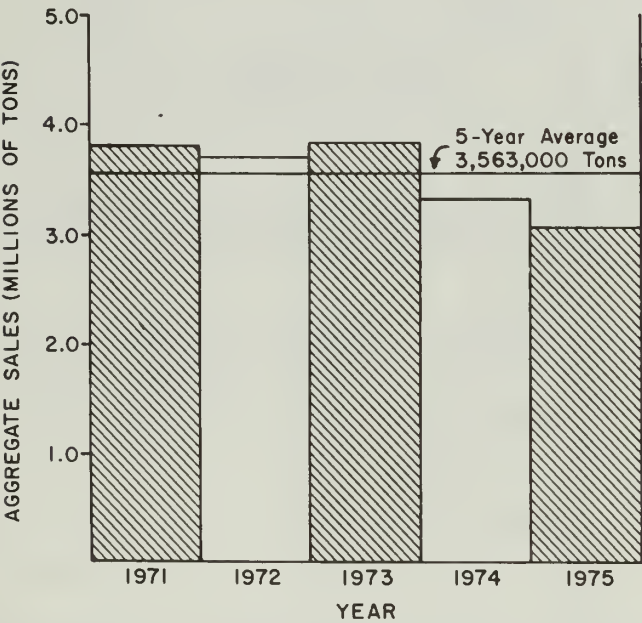


Figure 29. Lytle Creek fan-Upper Santa Ana River production district: Aggregate sales 1971 through 1975.

Reserves and Resources: Factors used in determining reserves for the district include:

- 1. Setbacks from property lines and flood control levees range 15 to 200 feet on the land side of levees, and up to 1,000 feet on the river side of levees.
- 2. Pit slopes range 1:1 and 1.5:1 along property lines to 5:1 and 20:1 along flood control levees.
- 3. Limitations to mining depth range from 15 to 200 feet.
- 4. The density of bank run material is estimated to be .063 tons per cubic foot.
- 5. Waste representing overburden and fine material discarded during processing ranges from 2 to 20 percent.

Taking into account the above factors, it is estimated that there are 8.1 m.t. of measured reserves and 290 m.t. of indicated reserves (table 24). The adjusted total reserves are over 240 m.t. Indicated resources are about 400 m.t. and inferred resources are over 1,600 m.t. The adjusted total resources are over 1,300 m.t. Based upon the average rate of production from 1971 to 1975, this district has sufficient reserves to sustain approximately 67 years of operations. If all resources were converted to reserves, approximately 370 years of life would be added to the district.

TABLE 24. Lytle Creek fan-Upper Santa Ana River production district: sales, reserves, and length of life for the district.

1975 Total Sales*	3,065,000
1971-1975 Average Annual Sales*	3,560,000
Total Reserves*	8.2 m.t. (M) x 1.0 = 8.2 m.t. + 290 m.t. (In) x 0.8 = 230 adjusted: 240 m.t.
M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	400 m.t. (In) x 0.8 = 320 m.t. 1,600 m.t. (If) x 0.6 = 960 adjusted: 1,300 m.t.
Estimate Life of District Based on 1975 Adjusted Reserves	240 m.t. ÷ 3.56 m.t./yr = 67 yrs
Estimated Extended Life of District if all Resources are Converted to Reserves	(240+1300) m.t. ÷ 3.56 m.t./yr = 440 yrs

* Short Tons
** See Reserves and Resources Calculation Factors Section

A larger volume of aggregate is present in the district outside the areas controlled by aggregate producing companies, but much of it is not presently available for extraction because the land is being used for agricultural, industrial or residential purposes. Insufficient information is available to estimate the quantity or quality of this potential resource.

Land and Water Use: Aggregate production is affected by specifications set forth in conditional use permits. These include Flood Control District permits or zoning regulations, air-pollution controls and water requirements.

Some of the small properties are now, or plan to be, reclaiming their depleted pits as sanitary landfill sites for Class III (inert) material. Most of the remaining properties are located in stream or flood control channels, and in debris basins where no reclamation is necessary.

Approximately 125 acre-feet of water is used each month for washing aggregate. Waste water from the plants is piped to settling basins where silt and clay drop out of suspension and some of the water percolates back into the ground water table. The amount of water recycled in the different plants varies from none to as much as 80 percent.

Environmental Considerations: Dust control measures include the use of spray bars that are installed close to crushing and screening facilities, and spraying water on haul roads. Fencing and setbacks are provided along property lines. Setbacks range in width from 15 to over 500 feet, and pit slopes are 1:1 to 20:1. Property boundaries are commonly landscaped as a beautification measure.

San Antonio Creek Fan – Cucamonga Creek Fan production district

General Data: The San Antonio Creek Fan–Cucamonga Creek Fan district is located 30 miles east of the Los Angeles Civic Center, straddling San Bernardino and the Los Angeles County line (figures 1 and 30).

Production first occurred in the district at the present site of Conrock Company's Claremont plant as early as 1909, and since then several companies have established operations there. Many of these companies, such as Mountain Rock Products Company and Central Rock Products Company, no longer produce. Presently there are six active producers (table 25).

Geology: In this district, aggregate is mined from two alluvial fans that are several miles apart at the mouths of San Antonio and Cucamonga Canyons on the south slope of the San Gabriel Canyon. The fans extend about eight miles in a southerly direction, with Cucamonga Creek and San Antonio wash extending past them for several more miles. The surface gradient of the fans is approximately 120 feet per mile.

Drill hole records show that alluvial material beneath the fan extends to depths of more than 700 feet. This material originates from the igneous and metamorphic complex within the San Gabriel Mountains and to the north, where elevations exceed 10,000 feet above sea level. During periods of heavy rainfall, large volumes of material including several varieties of granitic and mafic rocks, feldspathic gneisses, and schists, are transported into the drainage system for as far as 30 miles from the source area to the site of deposition. Although the deposit is poorly sorted, the coarsest material is generally deposited at the

head of the fan while the finest material is carried further downslope. Particles range from very large boulders down to clay size. Coarse material makes up 60 to 75 percent of the deposit where it is presently being mined.

Producers consider material processed from the fan to be of high quality. It is durable, relatively free of reactive and weak rock, and widely varied in particle size.

Production and Market Data: During 1975 production in the six plants operating in this district varied between 36,000 tons and 750,000 tons of aggregate. The average annual production for one plant was 390,000 tons. These plants produced washed concrete sand, gravel, unwashed sand, dust, crushed rock, base and fill. Aggregates were sold and utilized as outlined below:

Product Use	Percentage	F.O.B. Price Range (ton)
Concrete	45%	\$2.10–\$2.50
Asphalt	30%	\$1.92–\$2.60
Base	15%	\$1.45–\$2.12
Fill	10%	\$1.45–\$1.92
Other		\$1.72–\$2.40

Aggregate products are marketed in the surrounding communities in eastern Los Angeles, western San Bernardino, and Orange Counties. All the aggregate is shipped by truck.

In 1975, more than 2.2 m.t. (million tons) of processed aggregate were sold from production in this district (table 26). Over the 5-year period from 1971 to 1975, the average total sales from this district exceeded 2.6 m.t. per year (figure 31). Since 1960, the district has produced over 46 m.t. of aggregate, which represents about 6.7 percent of the total production for the entire study area for that period (table 26).

Extraction and Processing: Six plants in the district produce aggregate from pits that range in size from 25 to over 65 acres, with an average size of 35 acres. The pits range from 30 to 60 feet in depth.

The material is excavated by power shovels and hauled from the pits by trucks, except for one plant where a conveyor belt is used. Aggregates are processed in conventional plants that utilize both wet and dry circuits. This material is subjected to primary and secondary crushing, washing, sizing, and stockpiling.

Reserves and Resources: Factors used in determining reserves for the district include:

- 1. Minimum setback from property boundaries range from 25 to 200 feet.

2. Pit wall slopes vary from 1:1 to 4:1 (harizantal ta vertical ratia).
3. Pit depths range 20 to 200 feet.
4. Material density is estimated to be .065 tons per cubic foot.
5. Waste representing overburden and fine material that is discarded during processing ranges from 5 to 15 percent.

Taking into account the above factors, it is estimated that there are over 66 m.t. of indicated reserves. This figure renders an adjusted total of 53 m.t. of aggregate for the district (table 27). There are also 110 m.t. of indicated resources and 180 m.t. of inferred resources. These figures, taken together, render an adjusted total of 200 m.t. of resources. Based upon the average rate of production for

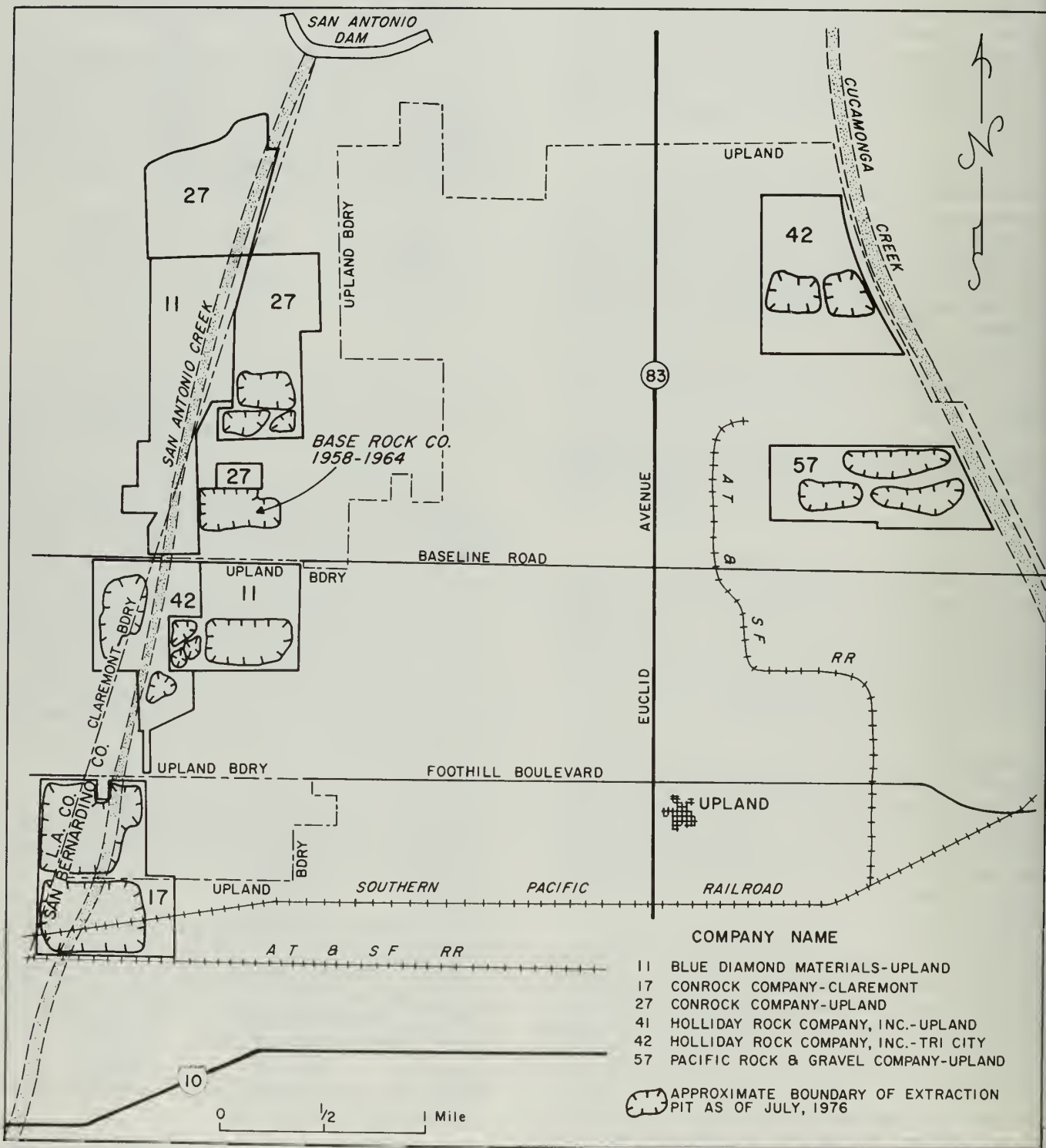


Figure 30. San Antonio Creek-Cucamonga Creek fan production district (see Figure 1): Sketch map showing land owned or leased by aggregate companies as of July 1976.

Table 25. San Antonio Creek fan-Cucamonga Creek fan production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
11	Blue Diamond Materials	Upland	S2 T1S R8W	Alluvial Fan	75	400	C,A,B,F,P
17	Conrock Company	Clairmont	S10,11 T1S R8W	Alluvial Fan	70	450	C,A,B,F,O
27	Conrock Company	Upland	S25,26,35 T1N R8W	Alluvial Fan	70	250	C,A,B
41	Holliday Rock Company	Upland	S2 T1S R8W	Alluvial Fan	75	250	C,A,B,F
42	Holliday Rock Company	Tricity	S29 (proj.) T1N R7W	Alluvial Fan	65	250	C,A
57	Pacific Rock & Gravel		S33,34 T1N R7W	Alluvial Fan	75	550	C,A,B,F,P,O

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)

** See Figure 2

the five-year period from 1971 to 1975, there are sufficient reserves to sustain 20 years of operations. If all resources are converted to reserves, an additional 75 years of life can be added to the district.

The alluvial fans emanating from the mouths of San Antonio and Cucamonga Canyons spread laterally for several square miles. A substantial portion of this is probably made up of commercially acceptable aggregate. However, the extent of this type of material has not been determined by subsurface investigation or laboratory testing. Because substantial urbanization has occurred over the fans, it seems doubtful that much of this potential resource could be developed even if large quantities of acceptable grade material could be demonstrated.

Land and Water Use: Aggregate mining and processing operations are subject to zoning restrictions which are set

Table 26. San Antonio Creek fan-Cucamonga Creek fan production district: Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	3,592,738
1961	2,652,390
1962	2,849,745
1963	2,549,080
1964	2,868,267
1965	2,442,441
1966	2,486,139
1967	1,966,668
1968	3,205,924
1969	3,696,808
1970	4,546,606
1971	3,285,461
1972	2,291,922
1973	3,019,108
1974	2,420,727
1975	2,284,713
TOTAL	46,158,737

forth by several different juridical entities in this district. Portions of the aggregate properties are located in Los Angeles County and some are situated in San Bernardino County. Therefore, permission to extract material and process aggregate is subject to the regulations of the particular county in which the deposit is located. Three of the aggregate producing companies have properties through which the county boundary passes. In addition to county regulations, supplemental ordinances are set forth by the City of Upland and the San Bernardino County Flood Control.

Flood control and ground water storage are of vital importance to the area and have an important effect on

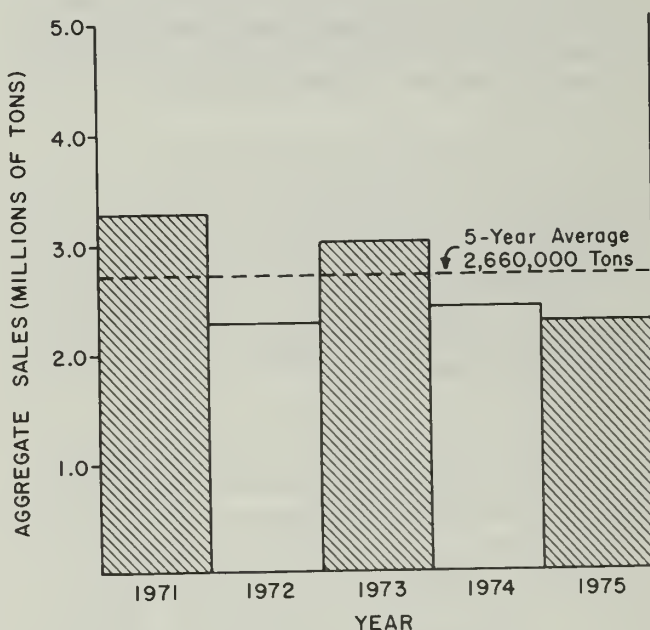


Figure 31. San Antonio Creek fan-Cucamonga Creek fan production district: Aggregate sales 1971 through 1975.

TABLE 27. San Antonio Creek fan-Cucamonga Creek fan production district: sales, reserves, and length of life for the district.

1975 Total Sales*	2,285,000
1971-1975 Average Annual Sales*	2,660,000
Total Reserves*	66 m.t. (In) $\times$ 0.8 = 53 m.t. + adjusted: 53 m.t.
** M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	110 m.t. (In) $\times$ 0.8 = 88 m.t. + 180 m.t. (If) $\times$ 0.6 = 110 adjusted: 200 m.t.
Estimate Life of District Based on 1975 Adjusted Reserves	53 m.t. $\div$ 2.66 m.t./yr = 20 yrs
Estimated Extended Life of District if all Resources are Converted to Reserves	(53+200) m.t. $\div$ 2.66 m.t./yr = 95 yrs

* Short Tons

** See Reserve and Resource Calculation Factors Section

mining operations. For example, operators located near Cucamonga Creek cannot excavate to a depth that will affect the ground water table or expose it to the atmosphere. Furthermore, during periods of flood storms, water channels cannot be diverted without expressed permission from the Chief Engineer of the San Bernardino Flood Control District.

Each month about 170 acre-feet of water are used in this district to process aggregate and control dust. Some of the water comes from company owned wells and some is purchased from the water company. After passing through the plant and into settling ponds, the water is either recycled back into the plant or allowed to seep back into the ground water table where it is available for reuse.

Environmental Considerations: Environmental problems for the San Antonio Creek Fan-Cucamonga Creek Fan district are similar to those of other production districts mentioned earlier. Flood control and ground water storage are important to the district and, as a result, special care must be exercised to protect the ground water from contamination.

Table 28. Lower Santa Clara River-Ventura production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
66	Southern Pacific Milling Company	Ventura	S5 T2N R2JW S28, 32, 33 T3N R23W	Stream Channel	40-50	150	B, F
63	Southern Pacific Milling Company	El Rio	S11, 14, 15 T2N R22W	Stream Channel, Floodplain	25-35	1000	C, A, B, F, P, O
65	Southern Pacific Milling Company	Saticoy	S6 T2N R21W S29, 31, 32 T3N R21W	Stream Channel	45-55	---	Inactive at Present
25	Conrock Company	Saticoy	S1, 11, 12 T2N R22W	Stream Channel, Floodplain	45-55	540	C, A, B, F, O
24	Conrock Company	Santa Paula	S11, 12 T3N R21W	Stream Channel	45-50	---	Inactive at Present
48	Livingston-Graham, Inc.	Santa Paula	S21, 22, 28, 29, 32 T3N R21W	Stream Channel	45-50	325	C, A, B, F, P, O

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)

** See Figure 1

Presently, there are plans to convert some of the pits into water recharge, storage, and debris basins after reserves have been depleted. In one case, there are plans to fill the depleted pit with sanitary land fill and later convert it into an athletic or recreational field. Conrock Company is beginning to use a portion of their pit located north of Claremont for Class II waste disposal.

Ventura County

Lower Santa Clara River - Ventura production district

General Data: The Lower Santa Clara River-Ventura production district is in Ventura County approximately 60 miles west-northwest of the Los Angeles Civic Center (figure 1, 32, 33). The district includes the Santa Clara River between Santa Paula and El Rio, a distance of seven miles, and the Ventura River adjacent to the city limits of San Buenaventura (Ventura), a distance of three miles.

Prior to 1925, records show production of aggregate in the Lower Santa Clara River-Ventura production district with two companies producing aggregate from three plants (Tucker, 1925, p. 223-245). Saticoy Rock Company operated one of these plants which had a 100 tons per hour (T.P.H.) capacity on or near the site of Conrock's Saticoy facility. Ventura Rock and Sand Company operated the other two plants; Plant # 1 was located on the Ventura River, apparently near the location of Southern Pacific Milling Company's present Ventura facility, with a capacity of 10 T.P.H. Plant # 2 was located on the Santa Clara River, 0.5 mile south of Montalvo, with a capacity of 30 T.P.H. (Tucker, 1925, p. 223-245). At present there are three companies operating six plants within the district (table 28).

Geology: This district is within the Ventura Basin, a synclorium with well developed anticlinal ridges and synclinal valleys, of which South Mountain and the Santa Clara

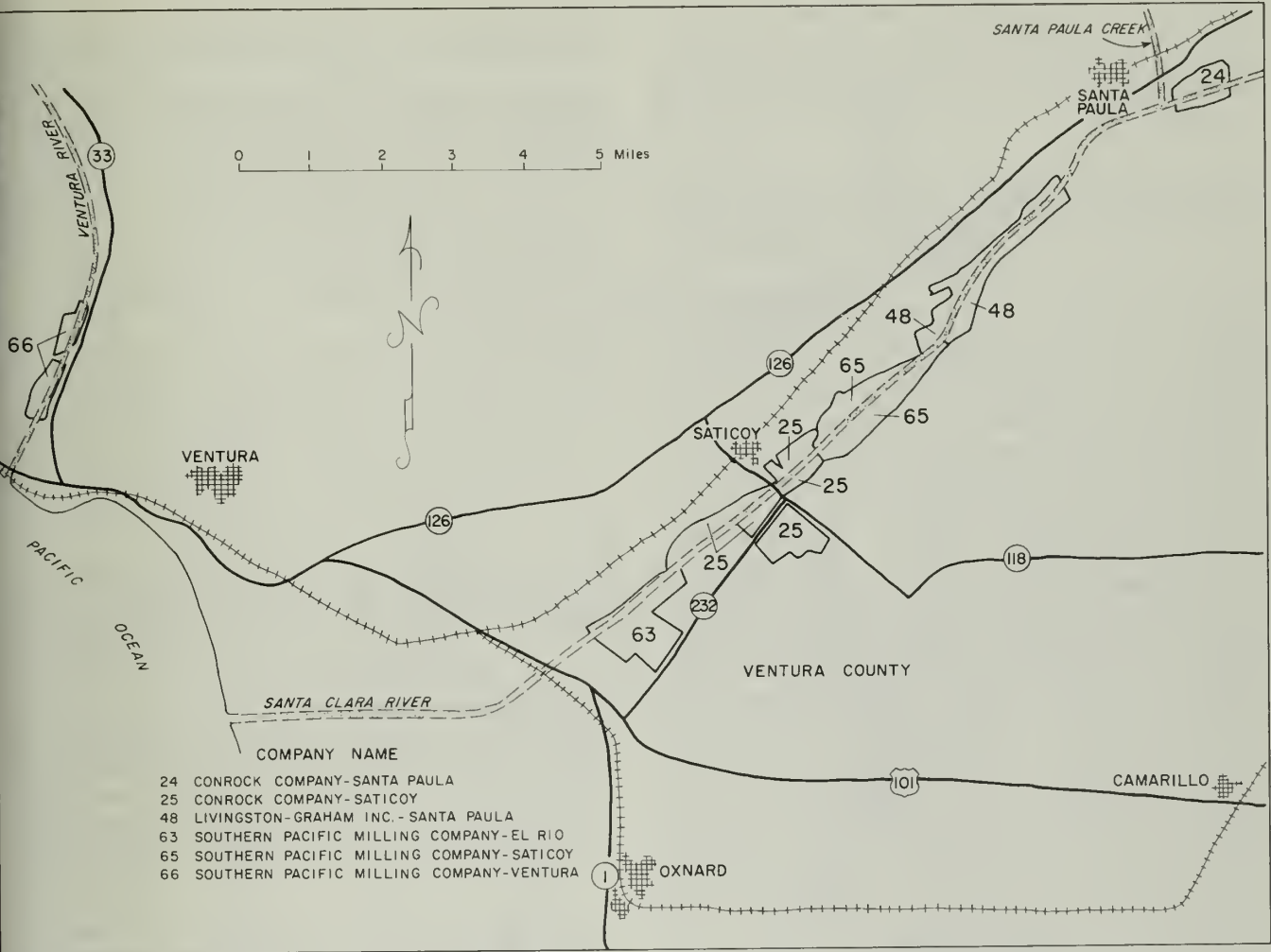


Figure 32. Lower Santa Clara River-Ventura production district (see Figure 1): Sketch map showing land owned or leased by aggregate companies as of July 1976.

River Valley are examples. Maximum local relief is 2,600 feet, with elevations of the valley floor in the production district ranging from 50 to 300 feet. A trellis drainage pattern has developed within this terrain, a direct expression of folding in the area.

The Santa Clara River flows westerly from its headwaters in the San Gabriel Mountains near Soledad Pass, 6 miles south of Palmdale. West of Saugus, the river flows through a synclinal valley. Detritus, which has been transported by the river and its tributaries, has been deposited along the Santa Clara River channel and on the adjacent floodplain to form a linear deposit ranging from 1 to 5 miles in width and up to 200 feet deep. The stream gradient is 28 feet per mile along the river from Santa Paula to its outlet in the Pacific Ocean, a distance of 10 miles.

The coarse fraction of the deposit (particles greater than one-quarter inch) decreases downstream with dis-

tance from its source (see Extraction and Processing, below). At Santa Paula, this fraction is estimated to be 40 to 45 percent and it contains boulders that measure up to three feet in diameter. The aggregate is composed of approximately 40 percent reworked sandstones, 40 percent granitic rock, 10 percent reactive Monterey Formation shales and 10 percent metamorphic and volcanic rocks.

The Ventura River flows southward from the junction of the two forks of Matillija Creek, approximately 17 miles north of Ventura. Its gradient is variable, but averages 57 feet per mile along most of its course. The gradient decreases to 32 feet per mile along the last 5 miles of the course, and near the city of Ventura it is 26 feet per mile. The sources of the aggregate within the river are Santa Ynez, Red, and Sulphur Mountains. The material is composed primarily of reworked Tertiary sandstones and shales, including reactive Monterey Formation shales.

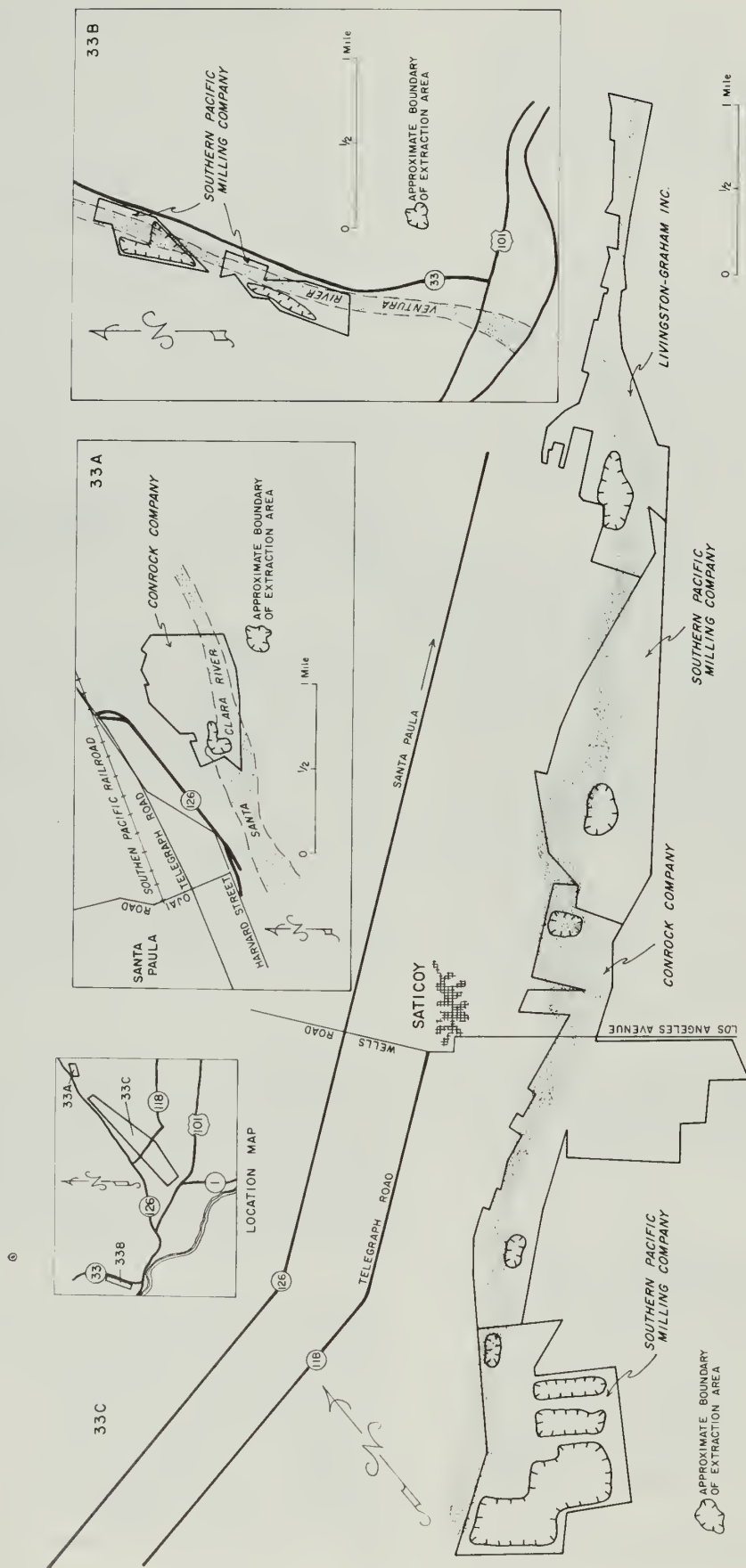


Figure 33. Sketch maps showing land owned or leased by aggregate companies in the Lower Santa Clara River-Ventura production district as of July 1976.

Aggregate products from this deposit are used for road material and fill sand because of the reactive shale content.

Production and Market Data: In 1975, the six active plants in the district had an average combined output of 392,000 tons (table 28), while individual plants produced from over 165,000 to more than 900,000 tons of aggregate. The material

Product Use	Percentage	F.O.B. Price Range (ton)
Concrete	37%	\$3.00-\$4.35
Asphalt	18%	\$3.00-\$3.25
Base	24%	\$2.20-\$2.65
Fill	15%	\$1.25-\$1.65
Other	6%	

The plants marketed their products in southern Santa Barbara, Ventura, and western Los Angeles counties. All of the aggregate is hauled by trucks owned by the producing companies or by independent operators.

In 1975, over 2.3 m.t. (million tons) of processed aggregate was sold from production (table 29). Over the five-year period from 1971 to 1975 inclusive, the average annual sales were over 3.1 m.t. (figure 34). Since 1960, the district has produced over 49 m.t. of aggregate, which represents about 7.0 percent of the output from the study area (table 29).

Extraction and Processing: In this district, three types of equipment are used for extraction: the power shovel, the front loader and the drag line. The drag line is used for extraction below the water table.

All of the producers extract material from the stream bed of either the Santa Clara River or the Ventura River. The properties represent approximately 57,000 linear feet

Table 29. Lower Santa Clara River-Ventura production district: Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	2,203,875
1961	3,118,511
1962	4,413,777
1963	2,236,365
1964	2,173,660
1965	3,567,431
1966	3,249,286
1967	2,881,386
1968	2,810,095
1969	3,606,401
1970	3,234,655
1971	3,810,853
1972	3,339,264
1973	3,771,282
1974	2,542,735
1975	2,356,819
TOTAL	49,316,395

along the channel and vary from 2,000 to 2,500 feet in width. Two of these operations also extract aggregate from the adjacent floodplain, where the properties vary from approximately 35 to 293 acres. A maximum depth of 70 feet has been attained in the pits from mining.

Aggregate is crushed, washed and screened with conventional equipment and augmented in some cases by special equipment for concrete aggregate production, as discussed below.

Washing and screening of material produces waste clay and silt that must be discarded. Within this district waste averages about 10 percent of the pit material and is determined by several factors including rock type, distance from source area, degree of weathering, and types of products sold. Lightly weathered anorthosite, gneiss, or granite is more durable during stream transport than Tertiary sandstones and shales, which are often moderately to highly altered by weathering. Approximately 10 percent of the aggregate in the Santa Clara River deposits and a significant but unknown percentage of material in the Ventura River deposit contains clasts derived from the Miocene Monterey Formation consisting of diatomaceous shales and opaline chert. This material is very reactive when used in concrete, causing cracking and "popout." Because of these problems, it must be removed prior to making concrete aggregate. The two methods of processing used to accomplish this affect the cost of production and have different degrees of effectiveness for removal of reactive rock. One method employs a heavy liquid mixture of ferrosilicon and water, with a specific gravity of 2.60 to float shale fragments from the heavier granitic material. The other method utilizes a jig to separate these fragments. Most of the lighter shale fragments are washed out of the aggregate and scalped off by a screen to produce an acceptable end product.

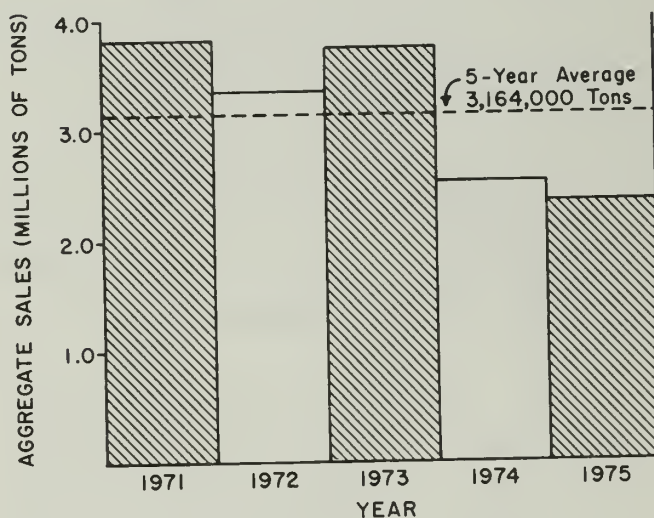


Figure 34. Lower Santa Clara River-Ventura production district: Aggregate sales from 1971 through 1975.

(figure 1, 35, 36, 37, 38). Included within this area are Oak Ridge north of Simi Valley and the Simi Hills to the south. The district extends 16 miles north-south and 20 miles east-west.

There is no known record showing when production began in this district. However, in past years aggregate has been produced from at least 10 distinct localities (Weber and others, 1973, plate 3). Three of these active plants are clustered around Santa Susana, while the fourth plant is north of Somis.

Geology: This district, which includes Oak Ridge and the Simi Hills within Ventura County, has a maximum elevation of 2,900 feet, and the local relief ranges from 600 to 1,900 feet. The ridges in the district are anticlinal structures formed within the Ventura basin. A trellis drainage pattern has developed within this folded terrain as reflected by the various tributary creeks that join the Santa Clara River, Arroyo Simi and Arroyo Las Posas.

P. W. Gillibrand Company and Tapo Rock and Sand Company are mining aggregate source material from the Pleistocene age Saugus Formation (figure 37). The pits in the north portion of P. W. Gillibrand Company's property and at the one owned by Tapo Rock and Sand Company are located in the basal part of the Saugus Formation. The material is composed of a light brown, slightly to moderately indurated pebbly sandstone and conglomerate containing coarse material that ranges from 10 to 50 percent of the volume. P. W. Gillibrand Company also is presently mining at the southern extent of its property, which is within the basal portion of the Saugus Formation and the

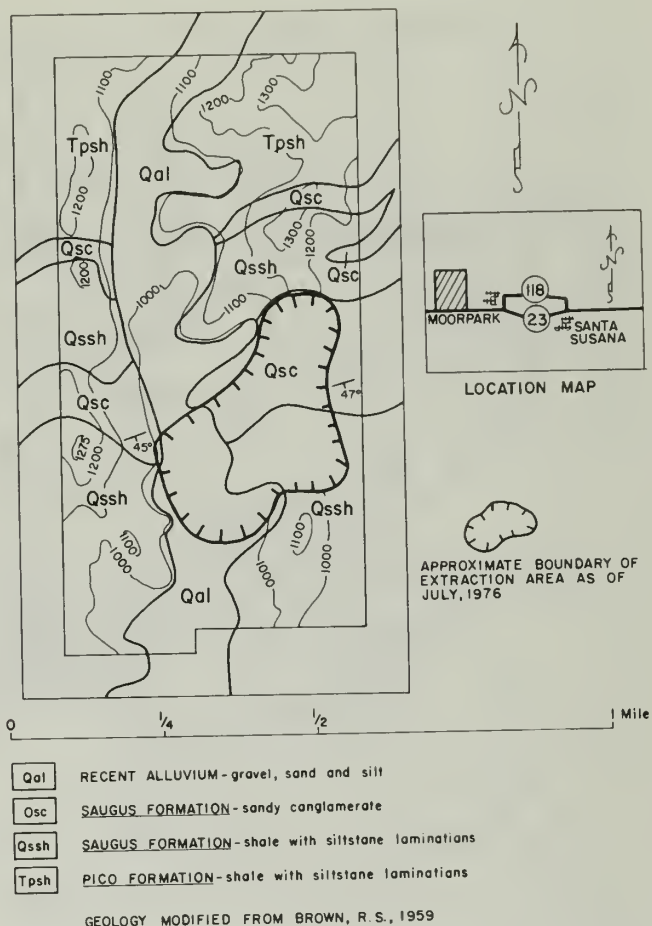


Figure 36. Geologic sketch map of Somis Rock and Sand Company's deposit.

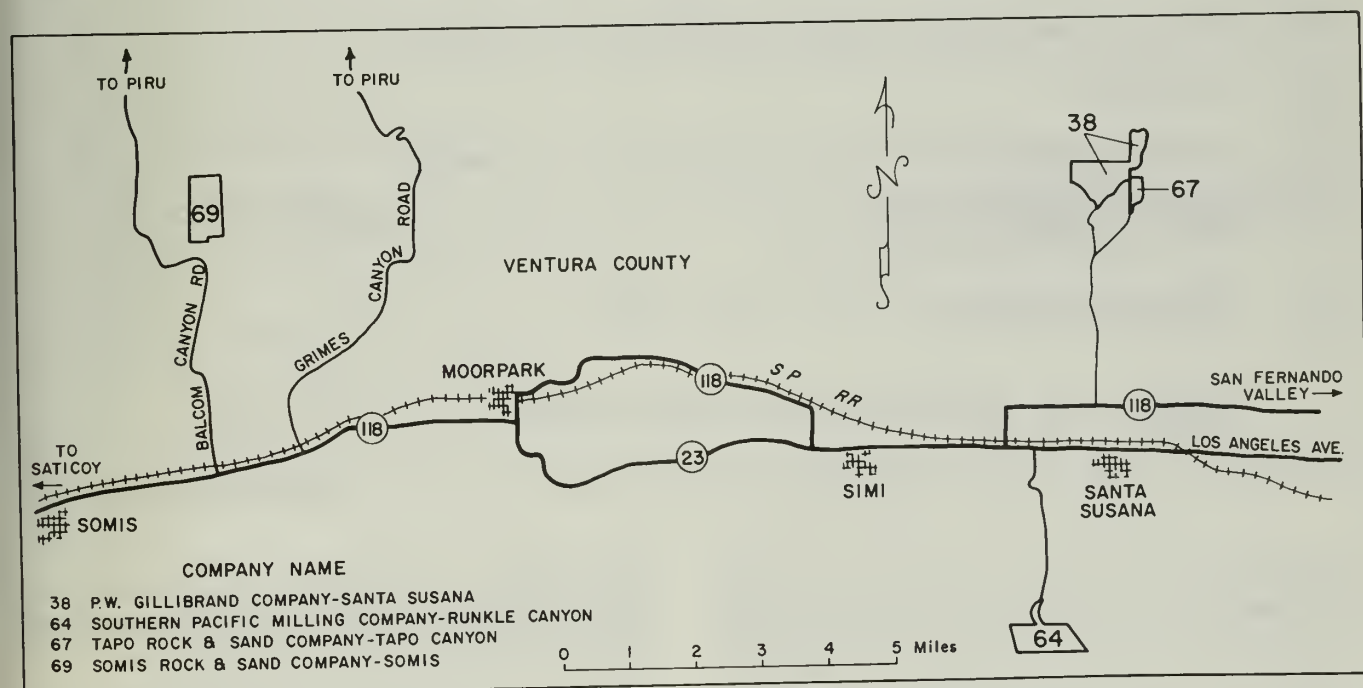
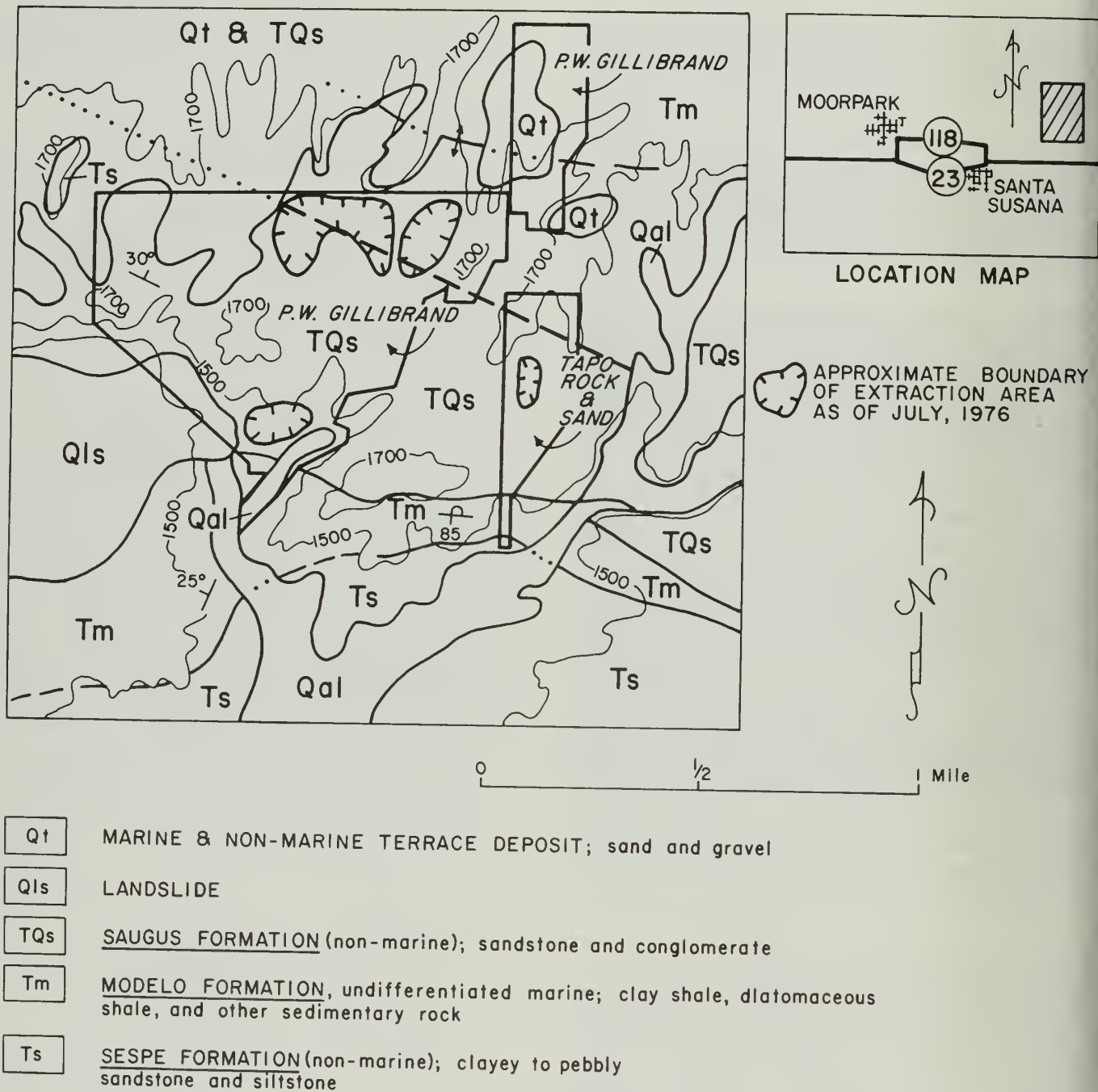


Figure 35. Simi Valley production district (see Figure 1): Sketch map showing land owned by leased by aggregate companies as of July 1976.



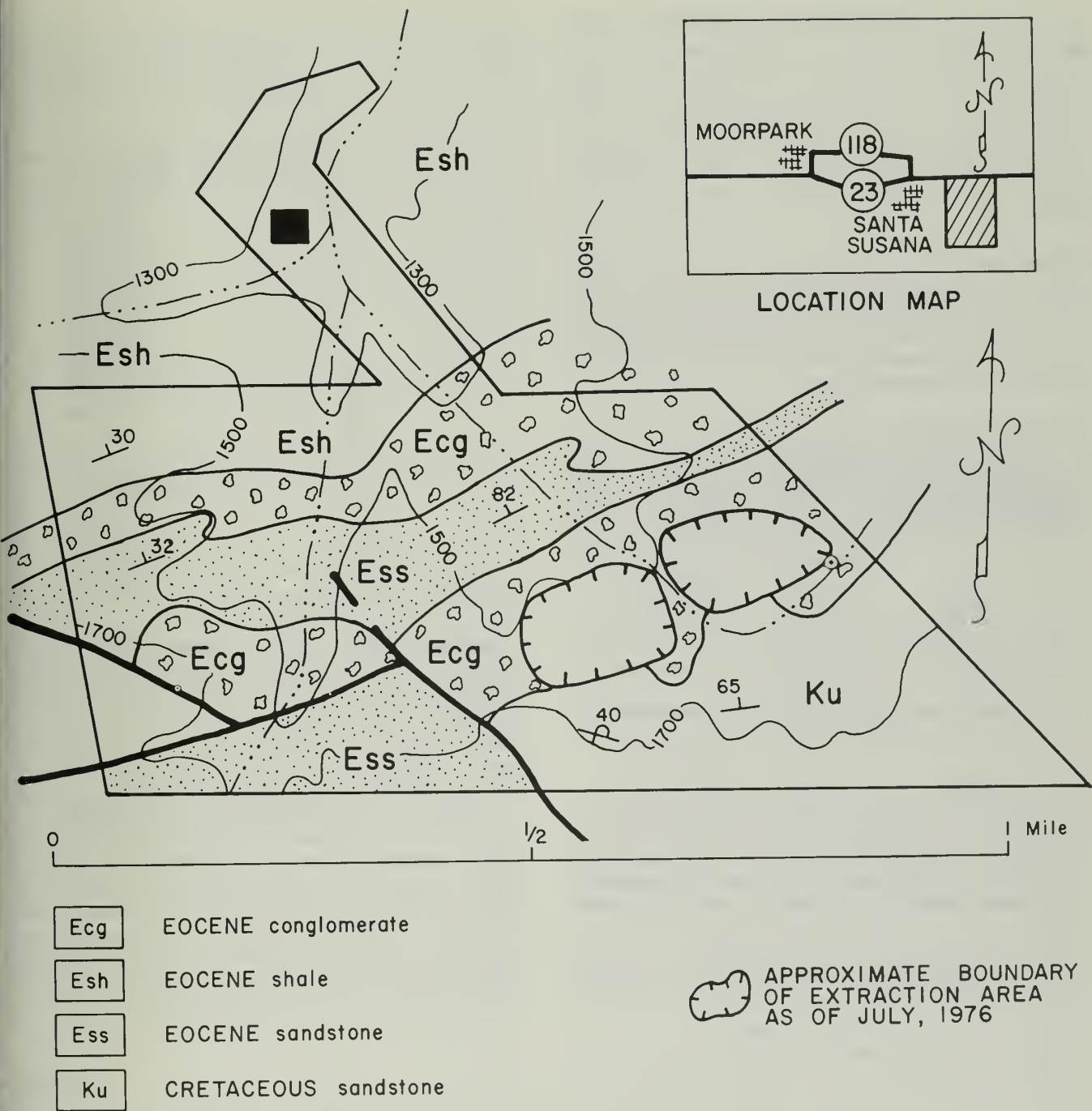
GEOLOGY FROM HEATHERINGTON, G.E., 1959, AS SHOWN IN WEBER, ET AL, 1973

Figure 37. Geologic sketch map of Topa Rock and San Company's deposit, Township 3N, Range 17W, Sections 18; 19, SBBM, and P.W. Gillibrond-Santo Paula Plant, Township 3N, Range 17W, Section 18, SBBM.

upper Pico Formation. The basal portion of the Saugus Formation at this locality is a fossiliferous marine pebbly sandstone and conglomerate, blue-gray in color and moderately indurated. Approximately 60 percent of the coarse fraction is composed of several varieties of granite; the remaining part consists of diorite, gabbro, sandstone, and

quartz-feldspathic schists. Locally, the upper Pico Formation is a white clastic sand, suitable for use as concrete and specialty sand (blasting sand, etc.).

Somis Rock and Sand Company mines aggregate source material from the San Pedro Formation, which is consid-



GEOLOGY MODIFIED FROM KEISSLING, E.W., 1969

Figure 38. Geologic sketch map of Southern Pacific Milling Company's Runkle-Canyon deposit, Township 2N, Range 18W, Section 25; 26, SBBM, latitude 34° 14' N, longitude 118° 44' W.

ered equivalent to the Saugus Formation (Weber and others, 1973, p. 23). The existing pit is located in the upper portion of this formation and is underlain by lower San Pedro and upper Pico Formation (figure 36). The clasts found in the San Pedro Formation are composed of approximately 50 percent granitic type rocks, 25 percent basaltic and andesitic varieties, and 25 percent mixed

quartzites, cherts, and gneisses. The white sands of the Pico Formation that are present in Tapo Canyon have not yet been found here. Material suitable for aggregate may occur within that unit on this property.

Southern Pacific Milling Company operates a plant in Runkle Canyon in the hills south of Simi Valley (figure

38). The deposit occurs within the Simi Conglomerate Member of the Paleocene marine Santa Susana Formation. The Simi Conglomerate, which follows a NE-SW trend across the eastern end of the Simi Hills, Simi Valley and Santa Susana Mountains, is offset by a left-lateral, strike-slip fault in Runkle Canyon. A relatively narrow bed trends east-west from south Burro Flats to Skeleton Canyon, north of Thousand Oaks (Weber and others, plate 1).

The conglomerate at Runkle Canyon is blue-grey, well indurated and partially cemented. Coarse material (greater than one-quarter inch diameter) represents from 65 to 70 percent of the aggregate, and it is composed of approximately 50 percent granitic rocks, 25 percent quartzite, and 25 percent metavolcanic rocks.

Production and Market Data: In 1975, four active plants in the district had an average output of about 300,000 tons, and individual plants produced from 225,000 to over 550,000 tons of aggregate (table 31). Material produced and sold includes:

Product	Percentage	F.O.B. Price Range (ton)
Concrete	30%	\$2.25-\$3.50
Asphalt	12%	\$2.65-\$3.25
Base	30%	\$2.00-\$3.00
Fill	16%	\$1.00-\$1.80
Other	12%	\$1.00-\$1.80

These are marketed in southern Ventura County and western Los Angeles County. All material is transported by company-owned or independent contractor-owned trucks.

In 1975, more than 1.2 m.t. (million tons) of processed material was sold from production (table 32). Over the

5-year period 1971-1975, the annual sales have averaged over 1.3 m.t. (figure 39). Since 1960, the district has produced over 16.6 m.t. of aggregate, which represents 2.4 percent of the output for the entire study area (table 32).

Table 32. Simi Valley production district: Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	52,609
1961	203,476
1962	126,310
1963	576,447
1964	508,000
1965	894,000
1966	1,186,000
1967	1,111,000
1968	1,869,000
1969	1,473,251
1970	1,719,255
1971	1,343,291
1972	1,387,690
1973	1,617,339
1974	1,306,241
1975	1,276,779
TOTAL	16,650,688

Extraction and Processing: Overburden is usually removed and stored on the property prior to mining. Throughout the district most material is mined from bedrock with a bulldozer. The material is then moved to a location where it is fed into a hopper by bulldozer or front loader. A belt conveyor then transports the material for distances up to 2,200 feet to the plant for processing. Less commonly, material is removed from a pit by front loader and then hauled by dump truck for distances up to 1,300 feet to the plant. Because all of the deposits are located on hillsides, excavation proceeds along side of the hills, following the slope, and terminates at a pit down slope. Economic extraction terminates where the overburden to aggregate ratio is approximately 1:1. Quarry and pit areas at the active properties range in size from about 2 to more than 68 acres.

Table 31. Simi Valley production district: Aggregate operations in July 1976.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4")	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
38	P.W. Gillibrand Company	Santa Susana	S18 T3N R17W	Bedrock	25-30	500	C,A,B,F,P,O
69	Somis Rock & Sand Company	Somis	S22 T3N R20W	Bedrock	15-20	300	C,B,F,P
64	Southern Pacific Milling Company	Runkle Canyon	S25,26 T2N R18W	Bedrock	60-65	650	C,A,B,F,O
67	Tapo Rock & Sand Company	Tapo Canyon	S18,19 T3N R17W	Bedrock	25-30	450	B,F

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)

** See Figure 1

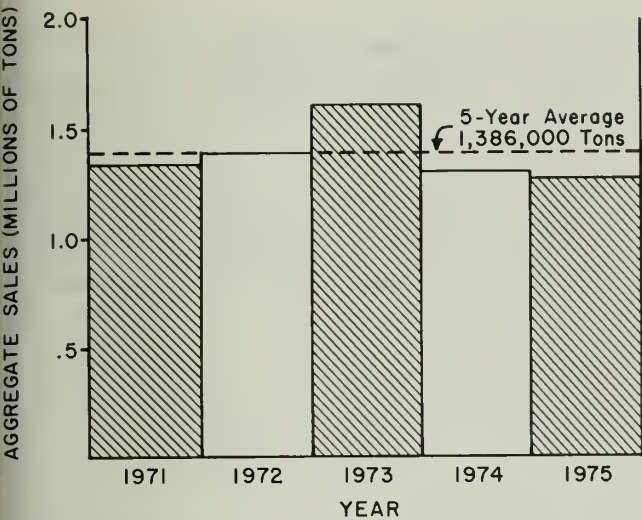


Figure 39. Simi Valley production district: Aggregate sales from 1971 through 1975.

At the plant, conventional portable or stationary equipment is employed to crush, screen and wash aggregate. Waste material, which can amount to as much as 15 percent of the gross volume, is piped to settling ponds.

Reserves and Resources: Factors that determine reserves for this district include the following:

1. Pit slopes range from 1:1 to 1/2:1.
2. Finished grades must be designed to prevent formation of standing bodies of water.
3. Occurrence and quality of material required for products such as waste factors, lack of coarse material, overburden and coarse/fine aggregate ratio are taken into account.
4. Material density ranges from .06 to .076 tons per ft.³
5. Waste representing overburden and fine material discarded during processing and unsaleable material ranges from 5 to 50 percent.

Taking into account the above factors, it is estimated that 2 m.t. of indicated reserves and 83 m.t. of inferred reserves are available (table 33). The adjusted total reserves are over 52 m.t. Based upon the average output from 1971 through 1975, there are sufficient reserves to sustain 37 years of production in this district.

Adjacent to, but outside, the production area along Oak Ridge and the Simi Hills within formations presently being mined, there are deposits of aggregate material much greater in volume than the deposits in the area being mined. However, most of this material is located in areas zoned for agricultural use. Also, present low market demand for aggregate precludes any immediate development of most of this material.

TABLE 33. Simi Valley production district: sales, reserves, and length of life for the district.

1975 Total Sales*	1,277,000
1971-1975 Average Annual Sales*	1,390,000
Total Reserves*	2.0 m.t. (In) x 0.8 = 2.0 m.t. 83 m.t. (If) x 0.6 = 50 adjusted: 52 m.t.
M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	None
Estimate Life of District Based on 1975 Adjusted Reserves	52 m.t. ÷ 1.39 m.t./yr = 37 yrs
Estimated Extended Life of District if all Resources are Converted to Reserves	No Extended Life

* Short Tons
** See Reserve and Resource Calculation Factors Section

Land and Water Use: The four active properties in this district have special or conditional use permits, which, in conjunction with air and water-quality discharge requirements, specify the conditions under which the operators may extract and process aggregate.

No formal reclamation plans were available at the time of this writing. The nature of the terrain at these properties suggests that grading of the quarry-pit areas could develop sites suitable for construction of residential or industrial buildings. Other possible uses for the graded sites might include parks or agricultural areas.

One of the four aggregate plants is a "dry" plant, employing water only for dust control. Each of the other three plants use approximately 70 acre-feet of water per month for washing and maintaining dust control. This water is supplied by wells located on the properties. After washing aggregate, water is piped into settling ponds where it is clarified. Most of this is recirculated back to the plant. The tailings in the settling pond are periodically dredged and then stockpiled on the properties.

Environmental Considerations: Spray bars, water-spraying trucks and road oiling are used for dust control around the plant and haulage roads. All of the aggregate plants are shielded from general view by the surrounding hills and landscaping is often provided along boundaries visible to the public from the roads. Fencing and setbacks are provided along property lines and slopes are graded as public safety measures. No maximum depths are specified by the various use permits.

Miscellaneous aggregate deposits

General Data: Aggregate is produced from four district locations which cannot be included into any of the 10 producing districts of the study area. Three of these deposits are located in Los Angeles County and the other is in Riverside County (table 34).

Table 34. Miscellaneous aggregate operations.

MAP NO.**	COMPANY	PLANT NAME	PLANT LOCATION	DEPOSIT TYPE	% COARSE MATERIAL (> 1/4"±)	RATED PLANT CAPACITY (tons per hour)	PRODUCTS*
12	Chandlers Palos Verdes Sand and Gravel Co.	Palos Verdes	S35 T4S R13W	Bedrock	2	300	C,B,F,P,O
58	Pasadena Aggregates Company	Devil's Gate Reservoir	S5,6,7,8 T1N R12W	Stream Channel	40	200	C,B,F,O
70	Rako Equipment Company	Montebello	S35,36,1,6, T162S R12W	Bedrock	50	125	F
62	Riverside Sand, Inc.	Pedley	S25 T2S R6W	Bedrock	—	300	B,F

* C = concrete aggregate; A = asphaltic aggregate; B = base; F = fill; P = plaster sand; O = other (e.g. float)
** See Figure 1

In Los Angeles County, Pasadena Aggregate Company mines sand and gravel from a stream deposit located in Arroyo Seco north of the Devil's Gate reservoir about two miles east of La Canada. The deposit is made up of clastic material that is derived from the San Gabriel Mountains to the north and is composed of several varieties of granite, quartz-feldspathic schists and gneisses. The aggregate is poorly sorted with about 40 percent consisting of hard, durable coarse material. The deposit is periodically replenished during periods of heavy rainfall.

On the northeastern flank of the Palos Verdes Hills, within the city limits of Rolling Hills Estates, Chandler's Palos Verdes Sand and Gravel Company processes aggregate mined from the Pleistocene age San Pedro Formation. The deposit occurs in a former marine terrace and is composed mostly of sand size particles. Most of the material processed is marketed in the south bay area, notably around San Pedro, Redondo Beach, and to a lesser extent in Santa Monica.

Approximately 10 miles east of the Los Angeles Civic Center, Rako Equipment Company processes aggregate mined from a bedrock deposit on the north slope of the Montebello Hills. The aggregate is extracted from the Saugus Formation and is made up mostly of sand size particles. The processed material is used locally.

Three miles northwest of Riverside and a mile southeast of Pedley in Riverside County, Riverside Sand Company mines a decomposed quartz diorite body. Because of the rock's decomposed state, most of the material mined at this location is sand size or smaller. The product is marketed primarily within a 15-mile radius of the plant.

Production, Reserves and Resources: In 1975, total production from the miscellaneous producers was in excess of 1.2 m.t. (table 35). During the five-year period from 1971 to 1975, the average annual production was slightly over 1.3 m.t. (figure 40).

Table 35. Miscellaneous production district: Aggregate sales from 1960 through 1975.

YEAR	TONS
1960	1,516,101
1961	2,481,467
1962	2,475,498
1963	2,230,543
1964	2,135,000
1965	1,771,000
1966	1,308,000
1967	1,181,000
1968	1,173,000
1969	1,046,202
1970	958,444
1971	1,206,234
1972	1,370,704
1973	1,381,970
1974	1,279,212
1975	1,268,337
TOTAL	24,782,712

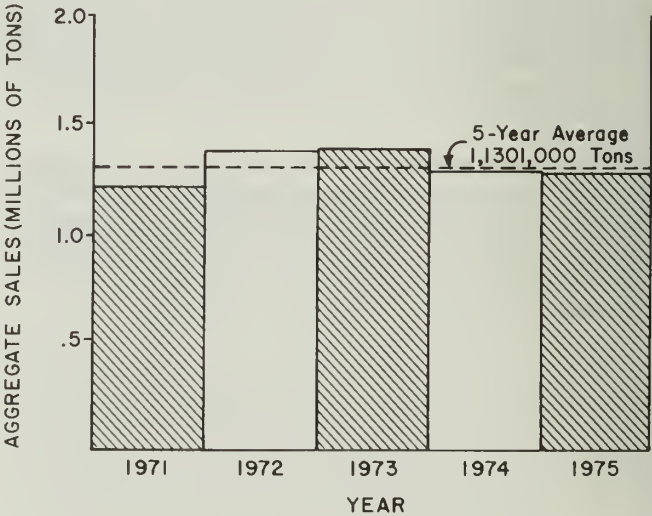


Figure 40. Miscellaneous aggregate operations: Aggregate sales from 1971 through 1975.

Distributed among the miscellaneous producers are over 8.8 m.t. of indicated reserves and 1.5 m.t. of inferred reserves (table 36). This yields an adjusted total of 7.9 m.t. of reserves. Based upon the average rate of production for the period from 1971 to 1975, there are sufficient reserves available to sustain 6 years of production. The inferred resources amount to 4.7 m.t. of aggregate, which gives an adjusted total resources of 2.8 m.t. for the miscellaneous producers. If these resources are converted into the reserve category, it could add two more years production for these producers.

TABLE 36. Miscellaneous aggregate operations: sales, reserves, and length of life for the district.

1975 Total Sales*	1,268,000
1971-1975 Average Annual Sales*	1,300,000
Total Reserves*	8.8 m.t. (In) x 0.8 = 7.0 m.t. + 1.5 m.t. (If) x 0.6 = 0.9 adjusted: 7.9 m.t.
** M - Measured; 1.0 factor In - Indicated; 0.8 factor If - Inferred; 0.6 factor	
Total Resources*	4.7 m.t. (If) x 0.6 = 2.8 m.t. + adjusted: 2.8 m.t.
Estimate Life of District Based on 1975 Adjusted Reserves	7.9 m.t. ÷ 1.3 m.t./yr = 6 yrs
Estimated Extended Life of District if all Resources are Converted to Reserves	(7.9+2.8) m.t. ÷ 1.3 m.t./yr = 8 yrs

* Short Tons
** See Reserve and Resource Calculation Factors Section

AGGREGATE SUPPLY AND DEMAND ANALYSES FOR THE GREATER LOS ANGELES AREA

Reasonably accurate projections of supply and demand for aggregates in the greater Los Angeles area, although difficult to make, are among the most important objectives of this study. Most previous studies of this subject have forecast aggregate demand primarily on the basis of population level and population growth rate. Although population figures are important indicators, taken alone they give an incomplete projection. For example, large tonnages of aggregates can go into new freeway and road construction; and other large public works are not necessarily related to population levels. The period between 1961 and 1975 was one of maximum new freeway and road construction in California, probably not to be repeated in the foreseeable future. Some new roads must be constructed, and also highway maintenance must continue, but probably not to the degree of the past. For these reasons and because (1) the construction industry is subject to unpredictable booms and busts; (2) land use reclamation and environmental factors can place strong constraints on the aggregate industry; and (3) mining, processing and transportation factors in the aggregate industry are sub-

ject to constant change; this study included consideration of a variety of conditions in analyzing and projecting supply and demand figures for aggregates in the greater Los Angeles area.

Total Aggregate Sales from 1960 through 1975

Total aggregate sold in the study area from 1960 through 1975 is about 690 m.t. In 1960, total annual sales had ranged from a low of about 31 m.t. to a high of about 51 m.t. in 1973. The average sales for the entire 16-year period from 1960 through 1975 was about 43 m.t. Cumulative curves showing the tonnage sold by production districts over the years 1960 through 1975 are presented in Figure 41. The San Gabriel Fan, Santa Ana Mountains-Coastal Plain, and the Tujunga Wash production districts have consistently had the largest production. Together these three districts make up about half of the total sales in the greater Los Angeles area for the 16-year period (figure 1).

Average sales for the period 1971 through 1975 were about 44 m.t., but the 1975 sales were only about 37 m.t., the lowest since 1960 (table 1). Since 1973, the total tonnage of aggregate sold in the study area has been decreasing but may stabilize if the construction industry strengthens and recovers.

Aggregate Flow Patterns

Virtually all of the aggregate produced in the 10 production districts in the 60-mile circle defined as the greater Los Angeles area (figure 1) is marketed within and between production districts. Aggregates are shipped from the Temescal Wash, San Gabriel Fan, San Antonio Creek Fan-Cucamonga Creek, and Lytle Creek Fan production districts into the Santa Ana Mountains-Coastal Plain district. The exact amount varies and is not known, but is believed to be between 1 and 2 million tons per year. The Simi Valley, Tujunga Fan and San Gabriel Fan production districts serve the central Los Angeles and the San Fernando Valley areas. Nearly all the aggregate produced in the Lower Santa Clara River-Ventura production district is sold there, and some additional material probably comes in from the Tujunga Fan production district. In the Little Rock Creek Fan production district, practically all the aggregate produced is sold locally. The same is essentially true for the Upper Santa Clara River production district, although some aggregates from that district are sold in the northern San Fernando Valley area.

In 1975, nearly all of the aggregate sold in the study area was transported by truck and trailer combinations. A minor tonnage was shipped by rail from Conrock Company's Reliance plant to the Santa Barbara area.

Factors that Affect Supply and Demand Analyses

Many factors affect supply and demand for aggregate in the greater Los Angeles area. The major factors discussed

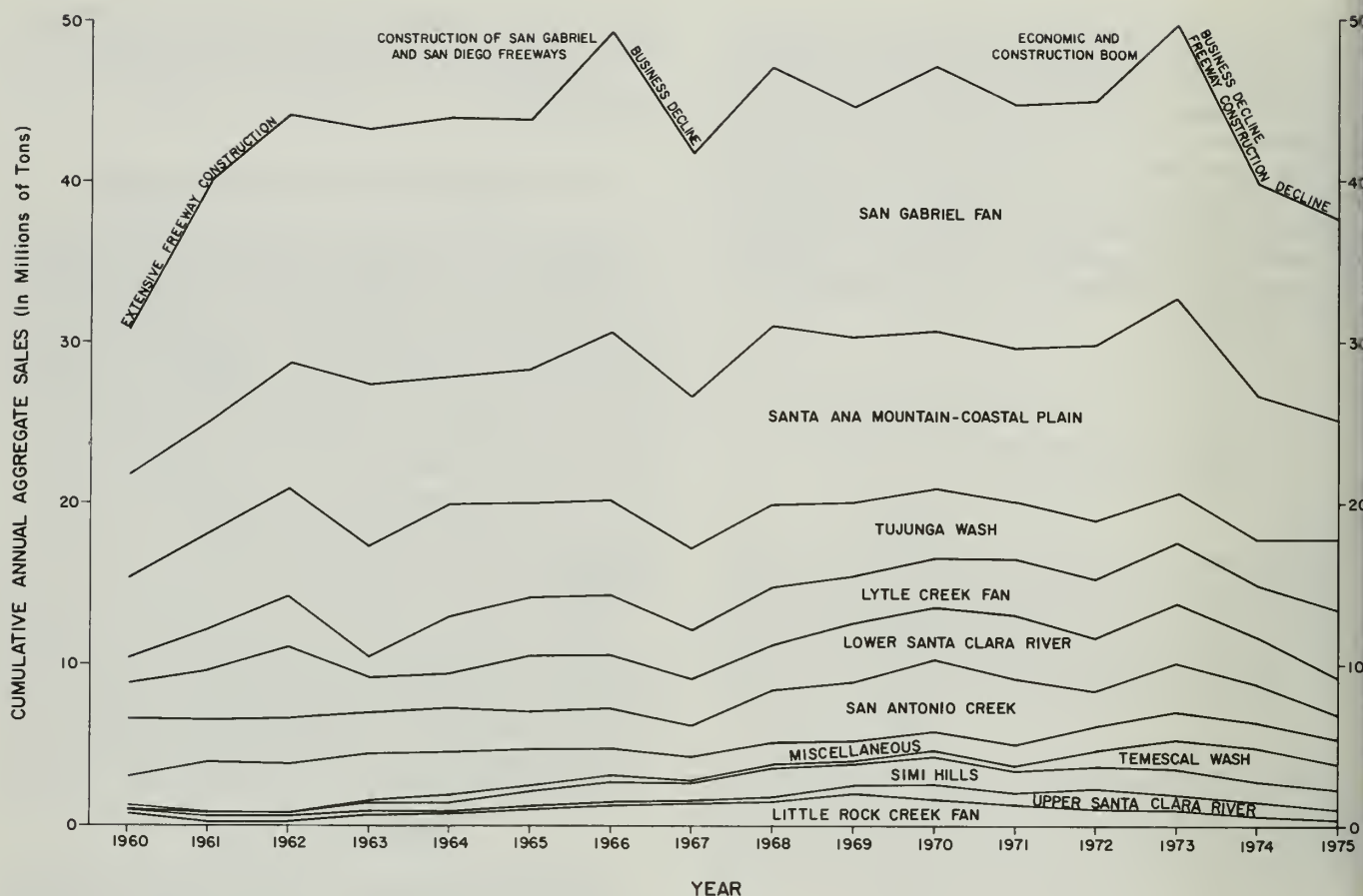


Figure 41. Cumulative sales from all aggregate production districts in the greater Los Angeles area. Top line represents cumulative total for area. Distance between lines represents sales from individual districts.

in this report are organized in five categories: (1) environmental and land use factors, (2) economic factors, (3) mining, processing, and transportation factors, (4) geologic factors, and (5) use of substitute materials.

Environmental and land use factors

The specific types of environmental and land use factors that must be considered by the aggregate producing industry, including reclamation, have been documented in the section on SUPPLY and also in APPENDIX II of this report. Only the broad aspects that influence extraction and marketing of aggregates will be discussed here.

Most counties and cities in the study area have zoning laws, and all the land within each governmental unit is zoned to indicate acceptable land uses. If mining is permitted in a zone and an aggregate company owns or leases land within that zone, the company may apply for a use permit or its equivalent to begin an operation. If the parcel to be quarried is on land under both city and county jurisdictions, permits must be obtained from each. An acceptable reclamation plan which meets the policies and guidelines of the State Mining and Geology Board must

also be approved by the city or county, as a condition for issuing the permit. Environmental concerns such as noise, dust, beautification, and storage of wastes, must be accounted for in a manner satisfactory to the governmental entity involved. Waste water discharge requirements are needed in most localities throughout the study area. They are obtainable from the appropriate State Regional Water Quality Control Board. If the deposit to be worked is on land controlled by a water or flood control agency, whether municipal, state, or federal, that agency's requirement must also be satisfied.

Nearly all new aggregate operations in the study area require an Environmental Impact Report (EIR). If an EIR covers all the subjects mentioned above satisfactorily, it should facilitate the approval process. An EIR, a reclamation plan, and a use permit application may all be required, with considerable overlap of subject matter. A complete EIR may cover all the problem areas at once, and facilitate acceptances.

Two main points are involved in environmental and land use factors. First, the aggregate industry must be concerned about any practices which can affect the com-

munity environment. An effective effort must be made to reduce air and water pollution, to reclaim pits after the operation is complete, and to improve the overall appearance of the operating aggregate mine, processing plant and transportation facilities. Secondly, the industry and community must recognize the time and costs required to protect the environment, and the importance of agreeing on fair and realistic environmental standards. As aggregates are a local commodity, the effect of supply deficiencies and cost of aggregates will effect the local community first. If land use and environmental regulations are reasonable, the time necessary to work them out is well spent. Undue delay and unreasonably high cost strongly affect the movement of aggregate into the market place. Also, overly stringent controls by the local government that prevent permits being issued to mine deposits can have adverse economic effects on the communities around them. These conditions make it difficult to accurately assess the possibility of plants going on-stream. When new plants do so, changes in the pattern of supply can be expected.

Economic factors

The aggregate industry is one of the most competitive of all industries. This competition, and the fact that supply areas are close to the demand or market areas, have kept the relative cost of aggregate low. Transportation costs and the significance of value-added costs have been discussed in the AGGREGATE INDUSTRY section of this report.

In the present market, it is not economically feasible for an aggregate producer to market his products too far from his plant. Assuming production costs are nearly equal, any competitor who is closer to the delivery point can deliver aggregate for a lower price because transportation costs are lower. Therefore, it is an economic advantage to any community to have nearby sources of aggregate so that delivered costs are reasonable. One way to guarantee continuing low aggregate prices is to protect a prudently large area of nearby lands that have high aggregate potential by zoning them for future extraction. Competition for other land use such as housing, agriculture, parks or recreational areas, along with public distaste for abandoned mined out areas surrounded by new homes, must be balanced against the long term community need for available low cost aggregate. In weighing the values of providing for a future aggregate operation, each community must also consider the large amount of aggregate used locally in state and federal public works such as dams, flood control works, freeways, as well as in local community road building and public buildings. Well over half of all aggregate produced in California is consumed in public works projects (Woodmansee, 1973, p. 18). The tax base and employment capacity as well as other economic considerations also affect the economy of a community.

Because the economic considerations of the aggregate industry are complex, with operations subject to unfore-

seeable external influences and local governmental regulations, it is difficult to predict if and when new deposits may come on stream. A company must be able to see a future return on its investment for land, amortization of mining and processing plants, equipment, costs of operations in general, and taxes paid out. A new company cannot enter the market nor can an existing company expand or embark on a new plant unless it is economically viable to do so. As with other marketing ventures, economic conditions may favor investment for an aggregate operation in one locality within the study area, but not in another only a few miles away. Similarly, a new or expanded operation may not be economically prudent one year, but become very favorable only a few years later. Economic situations are somewhat difficult to assess a few years into the future, let alone 20 years or more.

Mining, processing and transportation factors

All aggregate companies have a continuing challenge to maintain efficient mining techniques and processing plants. Loading, handling and hauling of aggregate also must be efficient. All this concern is necessary because of the highly competitive nature of the aggregate market.

To be competitive in today's technology, new large plants should be fully automated and computerized. They should be fed from the extraction areas by belt conveyer rather than trucks. Capital costs for new plants or the conversion of older plants will be high, but they should pay for themselves over time through their efficiency. The capital investment risk can be high in a competitive and unsure market, and the company must be reasonably assured of recovering its costs with a profit margin before it invests. This uncertainty is a major problem in projecting a supply-demand forecast.

Company data and information about the overall capital costs for any existing aggregate operation are generally unavailable. The following discussion reflects a reasoned estimate.

Cost estimates for development of two hypothetical aggregate facilities

The first hypothetical example is a 3,000 tons/hour fully automated aggregate processing plant capable of conversion to 4,000 tons/hour. If this plant could operate at full capacity 8 hours a day, 5 days a week and 45 weeks a year, it could produce, theoretically, 5,400,000 tons/year. (Any down time beyond normal maintenance periods planned for would reduce that theoretical output.)

It would take an estimated 20 million 1976 dollars for capital costs to acquire a deposit capable of sustaining this plant for 15 years. This capital outlay would be needed (1) to prepare environmental impact reports and other reports necessary to obtain proper permits, (2) to buy appropriate mining equipment, and (3) to build the plant and ancillary asphaltic concrete and concrete batch plant.

If all steps go smoothly, about two to four years after the time of inception the plant should be ready and cleared to go on full production stream. If more time is necessary, it will most likely be due to problems that arise during application for required permits.

A 15 year operating period is probably a minimum for amortization of an investment of this type. To sustain the plant for 15 years, reserves amounting to 81 million tons (15×5.4 m.t.) would be necessary. If the plant capacity were to increase during the planned 15 year period to as much as 4,000 tons/hour, the yearly output would be 7.2 m.t., which would make reserves of at least 110 m.t. tons necessary. Because the plant probably could not operate at its theoretical maximum capacity continually, it would not use up the computed reserves in 15 years. Nevertheless, for broad planning, reserves of 81 to 110 m.t. are a reasonable minimum.

The second theoretical example is a smaller plant, rated at 500 tons/hour, but capable of conversion to 700 tons/hour. Assuming this facility could operate at full capacity for 8 hours a day for 5 days a week and 45 weeks a year, it could produce 0.9 m.t./year. It would take an estimated 3.5 million 1976 dollars for all the front-end costs listed in the previous example and take about one to three years for the operation to go on full production stream. More time could be necessary if problems arise in the application for required permits.

Again, assuming a 15-year operating period to amortize the investment, the minimum reserves necessary would be 15×0.9 m.t. = 13 m.t. If the plant were to increase to 700 tons/hour capacity, or 1.3 tons/year, the minimum reserves required would be 19 m.t.

The first example represents a maximum design plant, while the second example represents one of the smallest practical permanent plants. Any new plant with less than 500 tons/hour capacity would probably be a portable plant. These examples were given to point out the approximate capital costs, the initial time lag before a new plant reaches full production, and the size of reserve necessary to support the plant facility. In both examples, particularly the larger facility, the operator must have reasonable assurance that his market will develop. If the larger facility were built expecting to serve a wide area, and previously unzoned and unpermitted deposits were suddenly zoned and permitted for extraction by a competitor, his planned market might be taken by a competitor and financial failure would result. On the other hand, if the planning factors are too unattractive, and no operator takes the risk of establishing new facilities, and existing deposits are depleted, then the community may face a real problem of high costs for its aggregate needs, depending on how close the alternate aggregate supplier is. This point will be further discussed in the FORECAST section of this report.

Although most aggregate in the Los Angeles area is now moved by truck and trailer, it may be possible or even necessary in the future to move it by rail. The network of freeways in the greater Los Angeles area makes it easy to transport aggregate by truck in 25-ton lots to other aggregate plants owned by the same company, and to concrete batch or asphaltic batch plants (figure 2; appendix 1).

Although a rail network exists in the area, and railroad transportation costs per ton-mile of aggregate is lower than for truck haulage, problems exist in the quantities involved and in delivery point flexibility. The low railroad cost per-mile is normally based on trainloads of no less than 15 cars each holding 100 to 150 tons; it is much more expensive to make up small loads. Further, to get the product from the railhead to the jobs throughout the market area still requires loading and truck haulage at the rail delivery end. If large distribution centers were established, offsetting costs would be required for handling, storage, reloading, and trucking. There are potential heavy traffic problems around distribution centers, and availability of land for centers in metropolitan areas would present additional problems. Conceivably, mined out aggregate pits within the area could be used for storage.

Geologic factors

The significance of geologic factors is that more deposits of marginal quality may have to be developed in the future than have been in the past in order to provide the necessary tonnage to meet the future demand. Many geologic problems can be involved in the development of any single deposit.

Proper geologic exploration, including mapping, drilling, trenching and laboratory testing, will be of critical importance in assessing new deposits, particularly bedrock deposits. Many of the stream and fan deposits being mined in current aggregate production districts contain good quality material, with nearly equal amounts of gravel, sand, and small amounts of waste. As these deposits become depleted, less desirable sources will be developed in bedrock, fan, or stream deposits. Reserves, waste factors, and waste storage factors will tend to be less favorable than in the past. Many millions of tons of rock may be available, but it may not be of proper quality or ratio of sand to gravel. In addition, the proportion of waste may be prohibitively high compared to present standards—perhaps as much as 25 to 40 percent. Grading in hillslopes with required slopes and setbacks may necessitate leaving large tonnages of material. Storage of waste from grading and mining operations may require filling of canyons and/or covering material that otherwise could be mined.

Use of suitable materials

Another factor which could affect aggregate supply-demand relationships is greater utilization of substitution

construction materials in place of concrete. For example, greater use of wood and steel in place of concrete could result in decreased demand for aggregate in future years. However, the use of slag from the Kaiser steel mills at Fontana, or crushed glass in place of rock material seems to be a greater possibility than the substitution of wood or steel for concrete. Crushed glass has never been used for aggregate in the greater Los Angeles area. However, from 1968 to 1975, slag was produced for use in aggregate from the steel mills by the International Mill Service, predecessor to the current operator, Hecket Slag (figure 1). Most slag is marketed locally because the f.o.b. prices are slightly higher than for rock aggregate. The potential effect of substitute material on the overall aggregate market is not known, but because of geographic and supply constraints, this study does not regard their impact to be large.

Aggregate Supply-Demand Forecast for the Greater Los Angeles Area

Methods of forecasting demand

Various methods have been used to forecast demand for aggregate, including regression and correlation analyses. Generally an attempt is made to estimate variations in demand by correlating that trend with some known factors such as population, gross national product, and/or other economic indicators. Statewide or locally, the total dollar value of building permits for engineered construction or for total construction have been used for correlation. A high level of construction generally indicates a high level of economic activity, and an increased demand for aggregate. Also population growth projections have been used to determine tons per person used. A community with a large population usually uses more aggregate than does one less populous. However, discordant relationships between construction activity, population growth, and aggregate sales (figure 3) show that mathematical computations using the above correlation factors alone are not suitable for an aggregate supply-demand forecast. Therefore, alternative forecast methods were tried and tested in an attempt to find one that would best represent conditions and trends characteristic of the greater Los Angeles area.

The method developed in this study for forecasting demand is based on the data presented in Figure 41. Note from Figure 41 that (1) there is no general steady upward trend of aggregate sales from 1960 to 1975; (2) sales of aggregate in each of the six largest production districts follow the same general trends during this period; and (3) cumulative total sales for the entire study area also closely reflect the individual sales trends of the six most productive districts. From 1960 to 1975, the average sales amount to approximately 43 m.t. per year. Furthermore, average yearly sales of aggregate for the 5-year period 1971 to 1975 differs by slightly over 1 m.t. above the 16-year average.

Based on the above mentioned factors and observations, it is reasonable to assume that foreseeable future average yearly aggregate demand in the greater Los Angeles area will not significantly deviate from the yearly average of the past 16 years. This figure, 43 m.t. of aggregate, presumably could be demanded—and sold—annually until the existing aggregate operations in the greater Los Angeles study area are depleted.

Forecast

The model used in this study, forecasts a continuing 43 m.t. per year aggregate depletion rate, and projects it into the future on a straight-line basis to predict how long the 1976 aggregate reserves and resources will last. The total 1976 area-wide aggregate reserves, including all the districts, is calculated to be 1,300 m.t. Dividing this figure by 43 m.t. per year, indicates that the total reserves for the entire study area will be exhausted in less than 30 years, or by the year 2005. This model, while reasonably accurate in the gross, is too simplistic to point up needs for planning and for adjusting production capacity among the production districts within the study area over the 30 year period. Consequently, a more refined analysis was developed on a district by district basis.

The ten production districts each have a different life expectancy, based on their individual reserves and depletion rates, as tabulated for each district in the SUPPLY section of this report. The refined model for depletion of the aggregate reserves of the Los Angeles region recognizes the reality that as each district is depleted of its reserves one by one, the nearby producing districts will very likely increase their production correspondingly to handle the resulting shortfall from market demand. This, of course, accelerates the rates of both production and depletion for the remaining producing districts.

If 1976 conditions of company land ownership and use permits granted do not change, then Figures 42 and 43 would graphically illustrate the steady-state model used in this study to forecast the life span of the greater Los Angeles aggregate production area. Table 37 tabulates data shown on Figures 42 and 43. Figure 44 illustrates the depletion pattern of total reserves in the greater Los Angeles area as well as for each production district. For example, in 1975 a total of 1,300 m.t. of reserves were available in the entire study area, and the part of that total in each district is shown along the vertical bar graph on Figure 44. Assuming that there is a 43 m.t. annual sales of aggregate, the portion that each production district will sell is shown on Figure 43. Applying this model, the Santa Ana Mountains-Coastal Plain production district would, in 1982, be the first district to be depleted of its reserves as shown on both Figures 43 and 44. This depletion date is based upon the fact that at the established rate of 10 m.t. of aggregate sold annually from its operating mines, the district's 1975 total reserves of approximately 65 m.t. will last about seven years. After the district has been depleted in 1982,

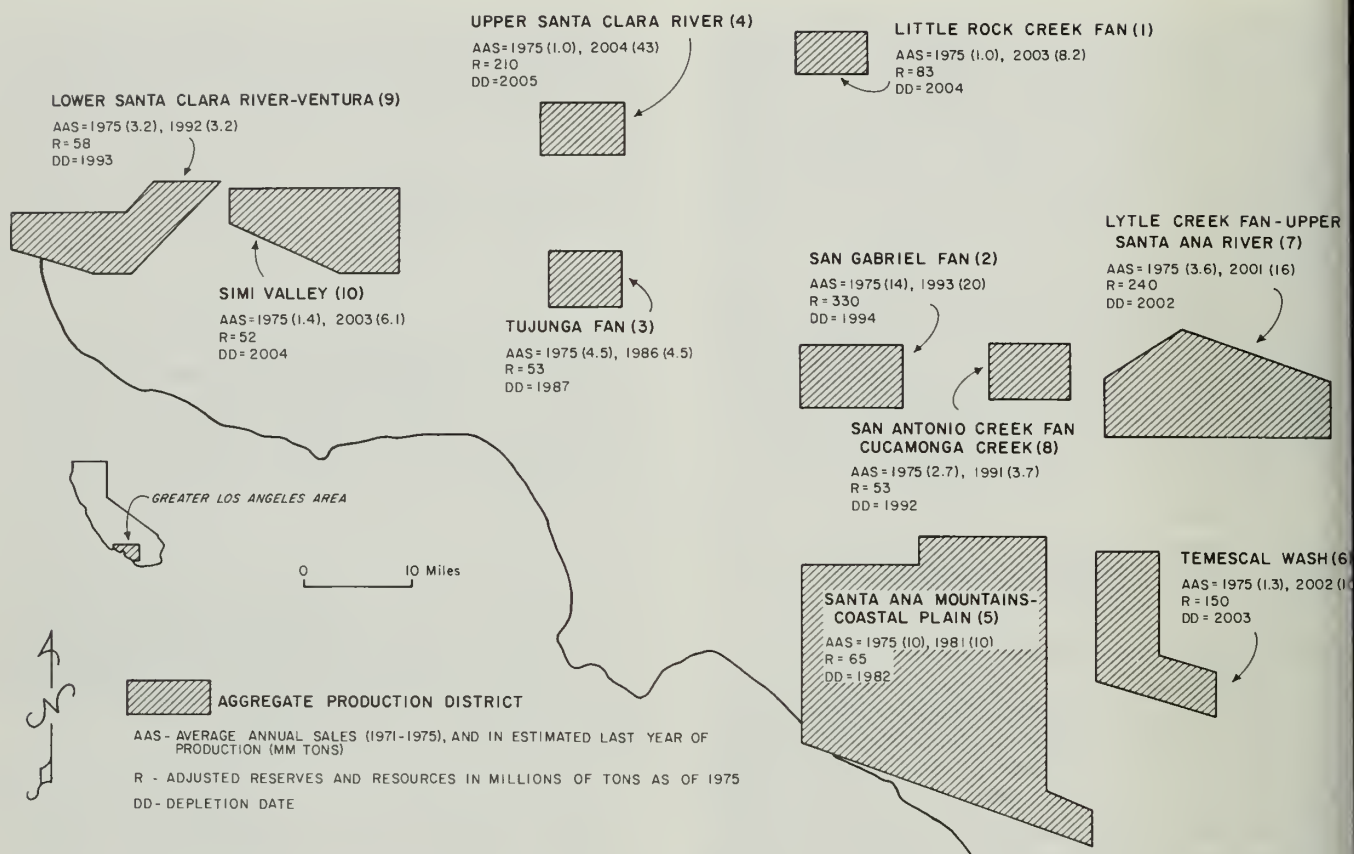


Figure 42. Sketch map of the greater Los Angeles area showing locations, average annual sales, reserves, and projected depletion dates of aggregate districts if company land ownership and use permits granted do not change from July 1976 status.

the 10 m.t. previously consumed from there must be supplied by part or all of the remaining districts, to continue to meet the total study area demand of approximately 43 m.t.

This rationale is followed for each district considered in this report, projecting up to the year 2005, when the total depletion of 1976 reserves is projected to occur and the last producing district is projected to be mined out. The allocation of an ever-increasing production capacity to an ever-decreasing number of districts over the next 30 years is a matter of theoretical estimation by the authors to illustrate the end point that will result if no adjustments are made to add to the 1976 reserves of each district. However, regardless of how the details of this allocation process are manipulated, it will not change the overall end point, always assuming that total demand remains at the projected rate and that no new deposits are converted to reserves and brought into production during the 30-year period. By 2002, only four districts would be active, producing the same total annual tonnage as did the ten districts which were operating in 1976. According to this model, the last extremity of the situation would occur in 2004, when only the upper Santa Clara River production district would be active, meeting the entire annual demand of 43 m.t. (table 38).

If all the presently identified *resources* were added to the *reserves*, and this depletion model followed, the overall depletion date would be extended to the year 2051. Figures 45, 46, and 47 graphically illustrate the steady-state model to forecast length of life of the greater Los Angeles area if resources are added to reserves. The data are tabulated on Tables 37 and 39. The assumption here is that all resources could be converted to reserves by the granting of appropriate permits. As can be noted in these figures and tables, the Lytle Creek Fan-Upper Santa Ana River production district would be the last to be depleted, instead of the Upper Santa Clara River district.

Forecast limitations

As this model of regional aggregate depletion approaches its final stages, it is obviously unreasonable that the one or two remaining active plants would be capable of handling the entire demand of 43 m.t. To do so would require them to establish enormous processing facilities, the equivalent of six plants of 4,000 tons per hour capacity. The problems associated with financing, constructing and operating this sort of development would be staggering. Transportation costs of distributing aggregate throughout the study area from only one source would require complete restructuring of the industry. Even if it were feasible,

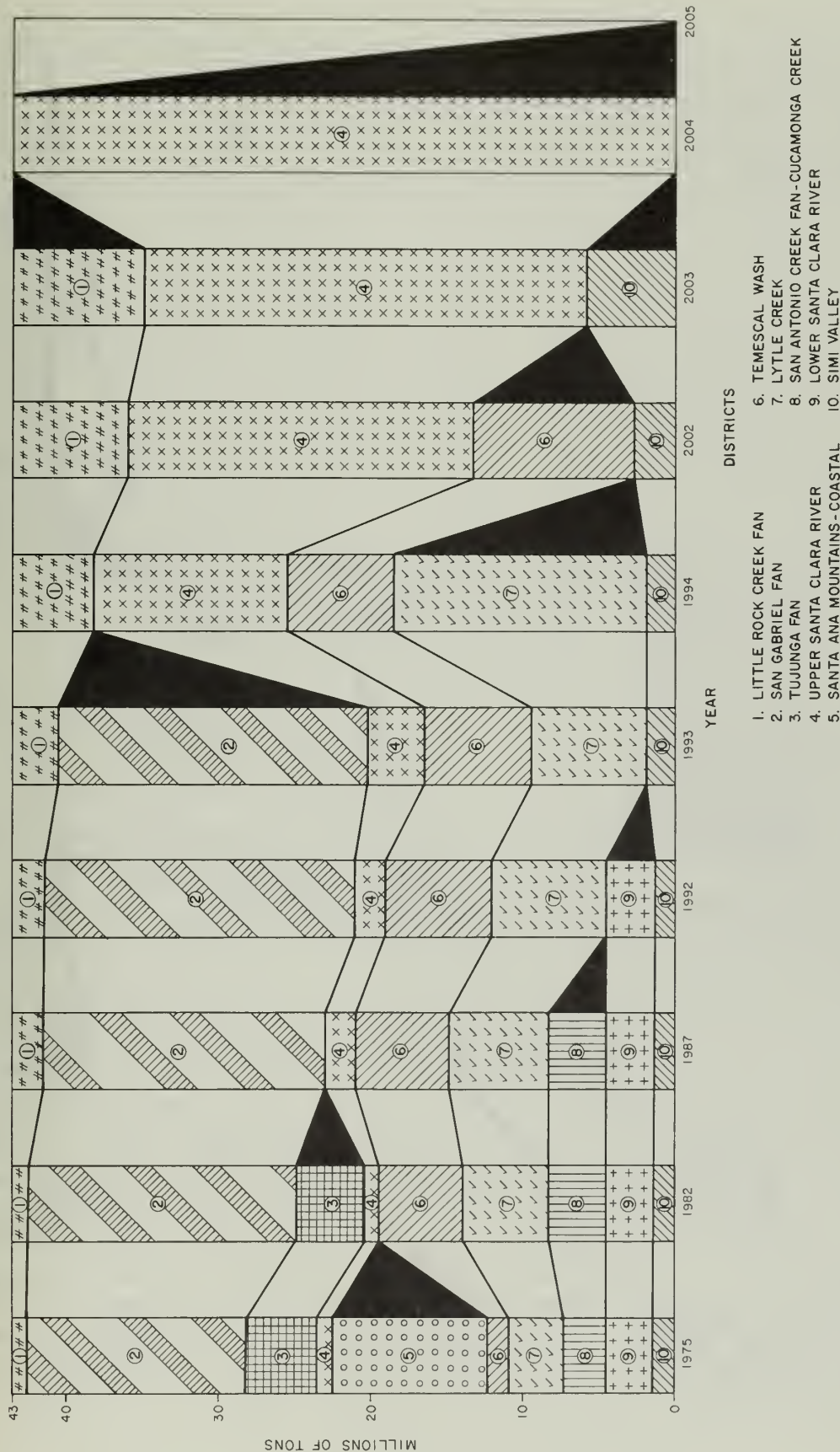


Figure 43. Projected distribution of aggregates sales for the production districts in the greater Los Angeles area needed to meet the estimated demand of about 43 million tons per year if conditions of company land ownership and use permits granted do not change from July 1976 status.

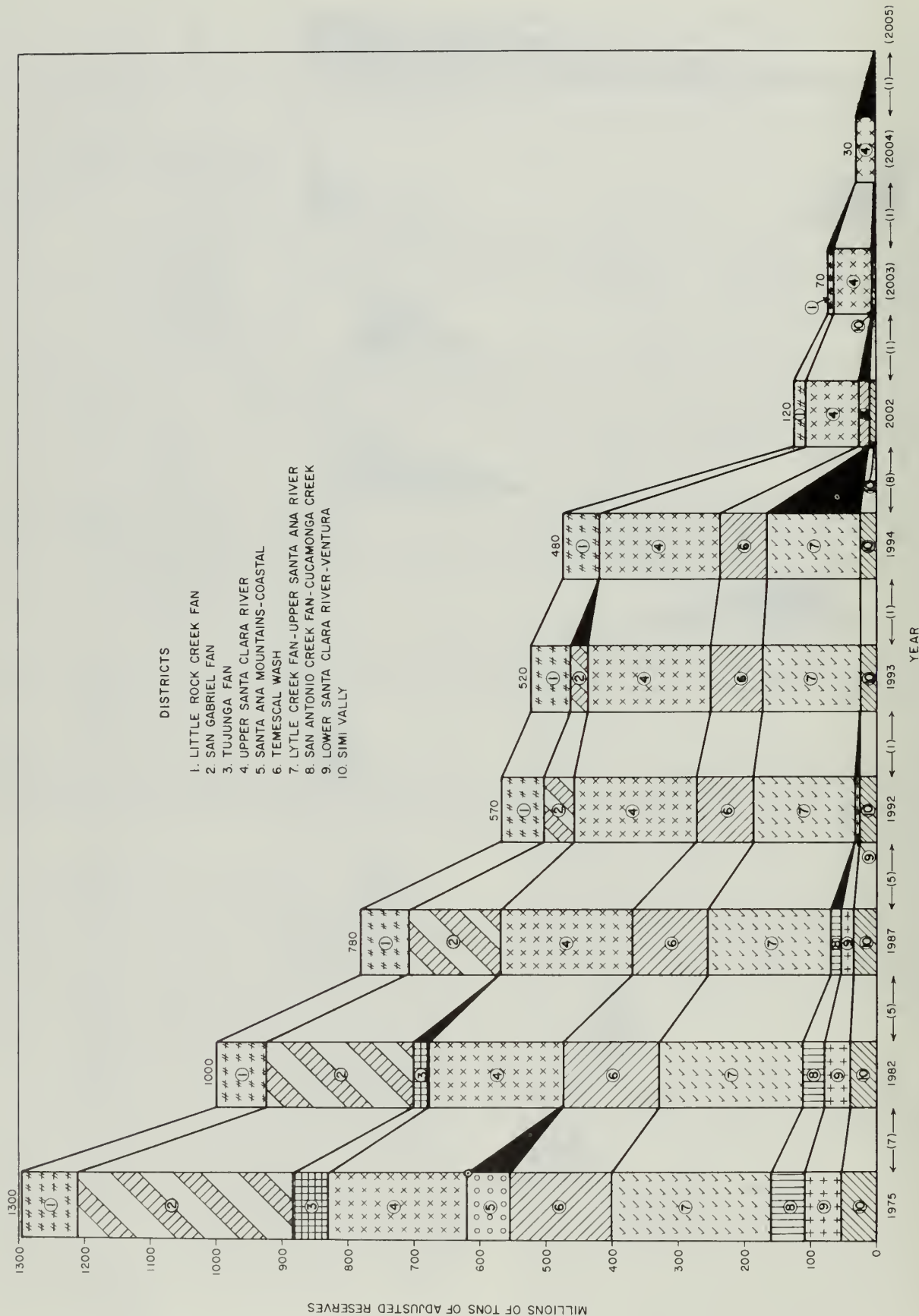


Figure 44. Projected life of the greater Los Angeles aggregate producing area and its 10 component production districts, based on about 1.3 billion tons of adjusted 1976 reserves and a continuing total demand for the entire study area of about 43 million tons of aggregate per year. It is also based on an assumption of unchanged aggregate company land and lease ownership and no changes in extraction permits from the July 1976 status.

Table 37. Summary of average annual sales, reserves, combined reserves and resources, and depletion dates of aggregate production districts in the greater Los Angeles area.

AGGREGATE PRODUCTION DISTRICT	AVERAGE ANNUAL SALES**	PROJECTED AVERAGE ANNUAL SALES IN LAST YEAR OF PRODUCTION**	ADJUSTED RESERVES AS OF 1975**	PROJECTED DEPLETION DATE	PROJECTED AVERAGE ANNUAL SALES IN LAST YEAR OF PRODUCTION**	ADJUSTED RESERVES AS OF 1975**	PROJECTED DEPLETION DATE
	RESERVES ONLY			RESERVES AND RESOURCES			
1. Little Rock Creek Fan	1.0	8.2	83	2004	4.0	110	2022
2. San Gabriel Fan	14.0	20.0	330	1994	18.0	530	2002
3. Tujunga Fan	4.5	4.5	53	1987	4.5	83	1994
4. Upper Santa Clara River	1.0	43.0	210	2005	6.2	220	2033
5. Santa Ana Mountains - Coastal	10.0	10.0	65	1932	10.0	140	1989
6. Temescal Wash	1.3	10.0	150	2003	3.0	240	2022
7. Lytle Creek Fan - Santa Clara River	3.6	16.0	240	2002	43.0	1500	2051
8. San Antonio Creek Fan - Cucamonga Creek	2.7	3.7	53	1992	8.7	250	2025
9. Lower Santa Clara River - Ventura	3.2	3.2	58	1993	3.2	88	2002
10. Simi Valley	1.4	6.1	52	2004	2.4	52	2008
	Total Reserves - 1300 million tons			Total Reserves plus Resources - 3300 million tons			
	Average depletion - 43 million tons per year			Average depletion - 43 millions tons per year			

**In millions of tons

Table 38. Projected aggregate sales (production) from 10 production districts in the greater Los Angeles area, needed to meet the 43 million tons per year demand, if no changes are made in company land ownership and use permits granted as of July 1976.

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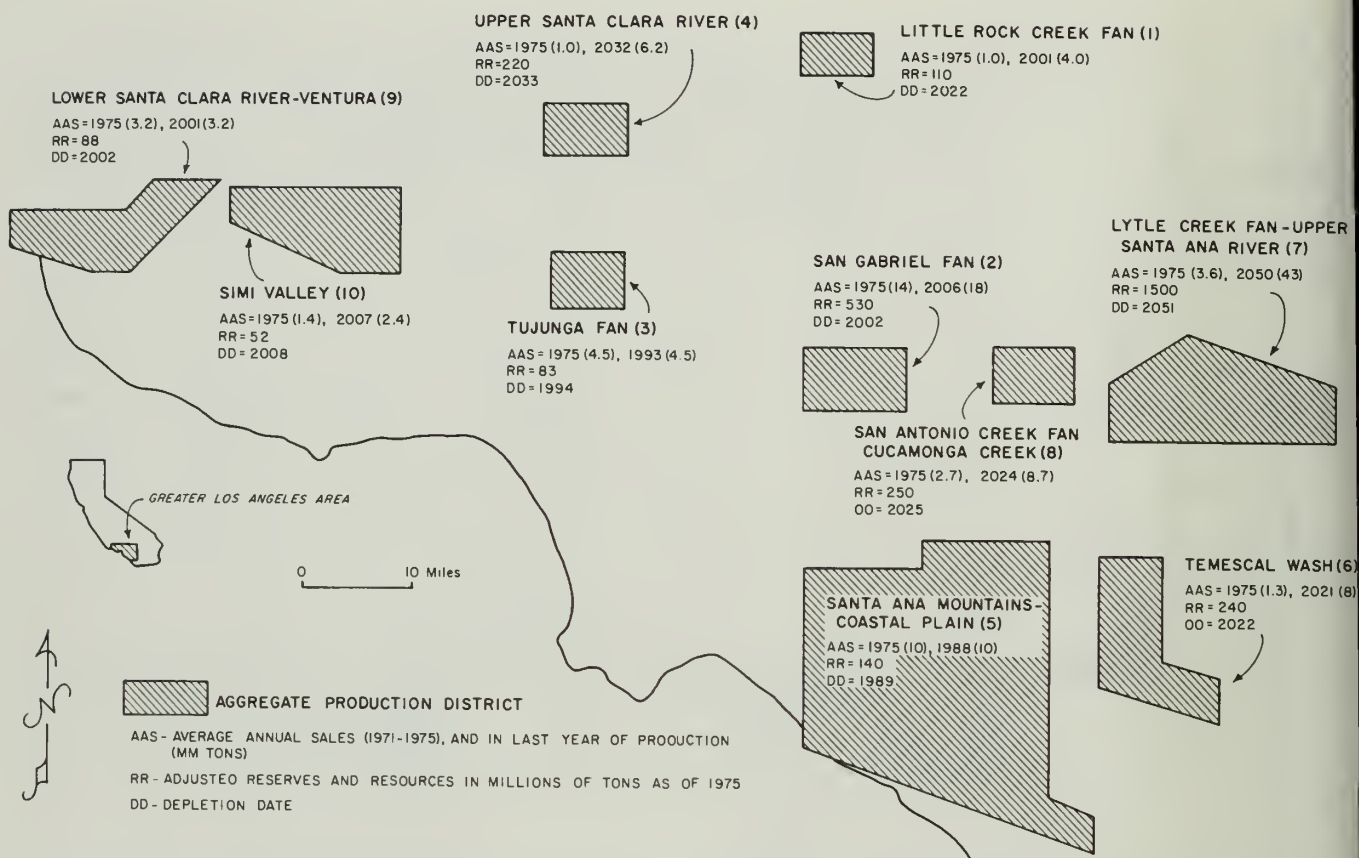


Figure 45. Sketch map of the greater Los Angeles area showing locations, average annual sales, reserves and resources, and projected depletion dates of aggregate production districts if resources are added to reserve.

such facilities would never be built unless there were strong assurances of the one-source market's continuing for the many years required to amortize the huge investment.

In pursuing this hypothetical district-by-district depletion model for the next 30 years, the forecasts have three obvious limiting assumptions: (1) that level of production/consumption would be maintained; (2) that no additional deposits would be added to the resources and reserves of the study area; and (3) that actual district depletions and successive replacements of lost capacity (which require major management and financial decisions on the part of every operator) would indeed occur in the order hypothesized. In spite of these limitations, this forecasting model is useful because it points out the inescapable depletion and closing of every producing district—and of the entire study area—in a relatively few years unless major specific actions and decisions are put into effect soon to prevent it. It shows that the overall pattern of supply must shift from the major districts currently producing to others which are relatively smaller and farther out today, or to other deposits that are presently not planned for, but that will be of major importance for the future. And technologically, as it becomes necessary to develop larger, more efficient processing plants in fewer

districts, new problems of transportation, storage, environmental protection, and quarry site reclamation will have to be solved. Probably the main lesson of this study is that planning and zoning actions must start soon, to protect these presently unplanned future reserves from incompatible uses (like housing developments) that will make them unavailable by the time they are needed for aggregate.

SUMMARY

In past years, the various population centers within the greater Los Angeles area have been served from local deposits of high quality material from which aggregate could be obtained at relatively low costs. From 1960 to 1975, total sales in the area ranged 31 to 51 m.t. of aggregate per year, and totaled approximately 690 m.t. for the 16-year period. For the 5 year period (1971 to 1976) average sales were 43 m.t. per year, almost all of which was produced within the study area.

According to the hypothetical depletion model developed for this report, which projects the above past 16-year average aggregate consumption (depletion) rate of 43 m.t. per year, the total supply of aggregate reserves that are presently committed for future aggregate usage in the

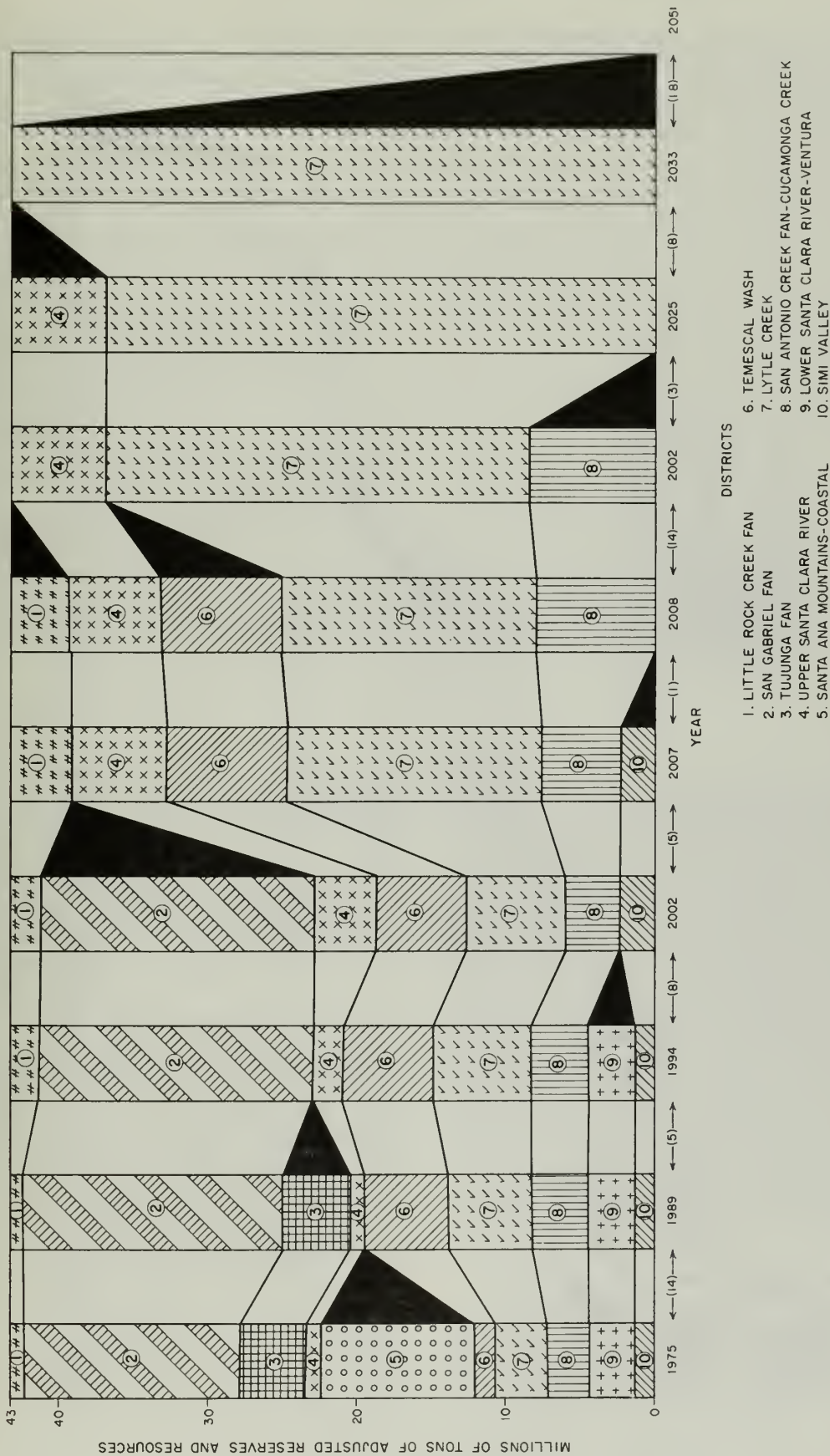


Figure 46. Projected distribution of aggregate sales for the production districts in the greater Los Angeles area needed to meet the estimated demand of about 43 million tons per year if resources are added to reserves.

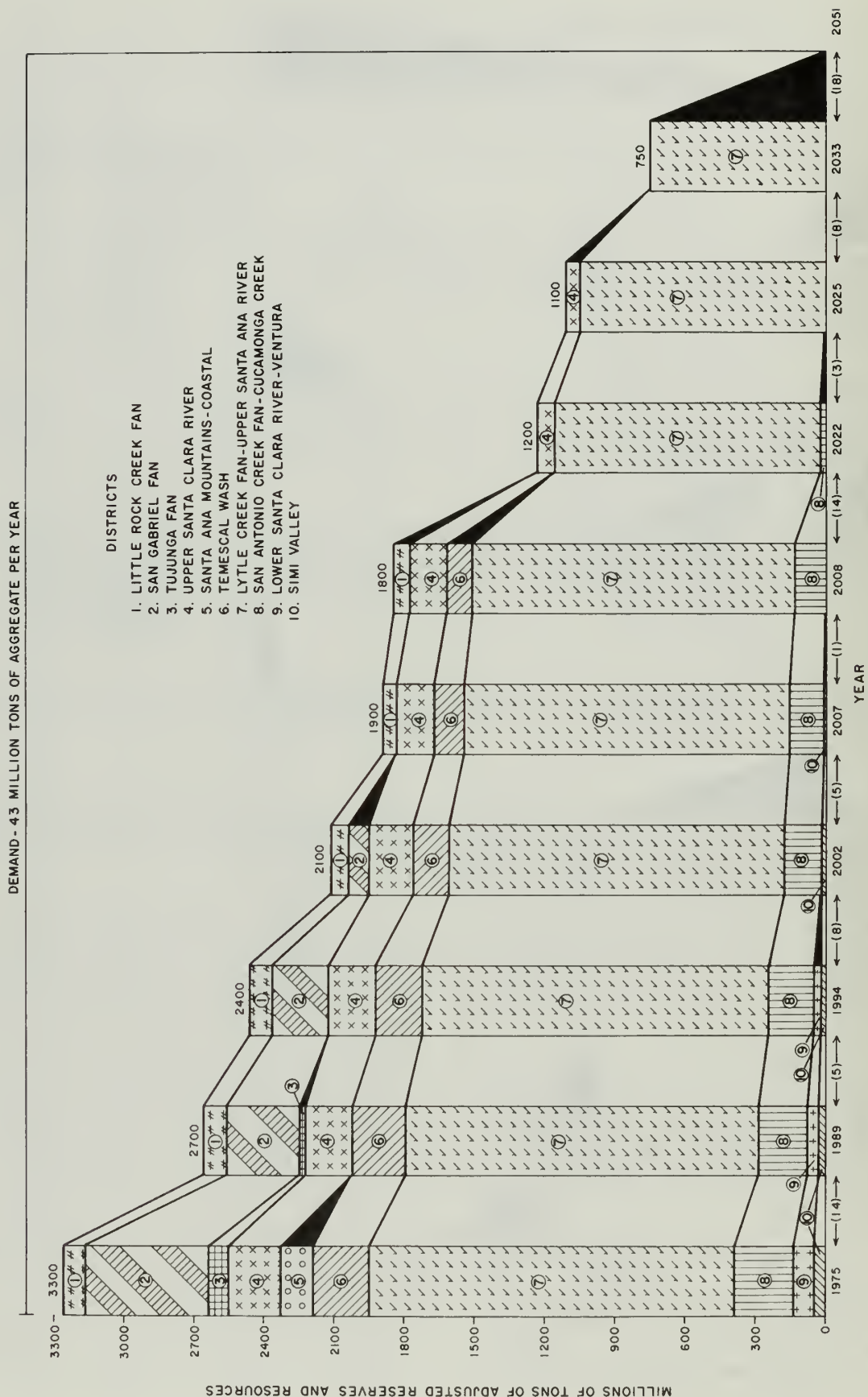


Figure 47. Projected life of the greater Los Angeles aggregate producing area, based on about 3.3 billion tons of combined adjusted 1976 reserves and resources, and a demand of about 43 million tons of aggregate per year.

Table 39. Projected aggregate sales (production) from 10 production districts in the greater Los Angeles area, needed to meet the 43 million tons per year demand, if resources are added to reserves.

AGGREGATE PRODUCTION DISTRICT	SELECTED PRODUCTION YEARS BETWEEN 1975 - 2051								
	1975	1989	1994	2002	2007	2008	2022	2025	2033-2051
1. Little Rock Creek Fan	1.0	1.0	2.0	2.0	4.0	4.0	----	----	----
2. San Gabriel Fan	14.0	17.0	18.0	18.0	----	----	----	----	----
3. Tujunga Fan	4.5	4.5	----	----	----	----	----	----	----
4. Upper Santa Clara River	1.0	1.0	2.0	4.2	6.2	6.2	6.2	6.2	----
5. Santa Ana Mountains - Coastal	10.0	----	----	----	----	----	----	----	----
6. Temescal Wash	1.3	5.5	6.0	6.0	8.0	8.0	----	----	----
7. Lytle Creek Fan - Upper Santa Clara River	3.6	5.6	6.6	6.6	17.0	17.0	28.0	37.0	43.0
8. San Antonio Creek Fan - Cucamonga Creek	2.7	3.7	3.7	3.7	5.7	8.0	8.7	----	----
9. Lower Santa Clara River - Ventura	3.2	3.2	3.2	----	----	----	----	----	----
10. Simi Valley	1.4	1.4	1.4	2.4	2.4	----	----	----	----
TOTAL	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

greater Los Angeles area (includes only those aggregate deposits for which extraction use permits have been granted) is sufficient for perhaps 30 years, or to the year 2005. If all presently identified aggregate resources (those deposits which exist within aggregate company controlled land, but for which no use permit has been granted allowing extraction) were added to the reserves, according to this depletion model the overall depletion date would be extended to the year 2051.

The above mentioned reserves and resources are present in ten geologic/geographic designated localities (production districts) which are unevenly distributed over the study area. The present aggregate reserves/resources in the ten production districts are grossly unequal and unrelated to the size (demand) of adjacent consuming population centers. As a result, some production districts within the greater Los Angeles area will become depleted in aggregate before others. The model used in this report assumes that, as each district becomes depleted, the remaining districts will have to supply the resulting shortfall in order to fulfill the projected 43 m.t. per year demand. If only current *reserves* (as the term is used in this report) are considered, the Upper Santa Clara River district would be the last production district to be exhausted in the year 2005. If *resources*, (as the term is used in this report) are added to the current reserves, the Lytle Creek Fan-Upper Santa Ana River production district would be the last district to become depleted in the year 2051.

As elsewhere, aggregate supply in the greater Los Angeles area is not solely dependent upon the actual occurrence and distribution of aggregate source material. Numerous interrelated factors affect the local available supply, such as environmental and land use factors, economic factors, geologic factors, and technological factors. The local aggregate supply can greatly be affected by environmental and land use policies and regulations imposed by local government agencies. Such actions have the effect of either precluding, impeding, or inviting new, continued, or expanded aggregate extraction. General economics also greatly influence supply, in that a company must be able to see an acceptable future return on its investment for land, amortization of mining and processing plants, equipment, costs of operations in general, and taxes paid out. Local government policy can influence this aspect of aggregate supply, either by encouraging or by discouraging capital investments necessary for the development of economical aggregate-processing operations.

Available aggregate sources in the greater Los Angeles area are rapidly being depleted. Unless responsible land use planning and aggregate industry supportive action is undertaken by the respective local governments within the Los Angeles area, potential aggregate sources in near-market production districts will be lost to incompatible land use and more distant aggregate sources will be required to supply the needs of the area. The increased haulage distance will result in significantly higher delivery

cost per ton, add to freeway congestion and fuel consumption, and contribute to other related problems.

RECOMMENDATIONS

In order to maintain a supply of reasonable low cost aggregate in the Los Angeles area, effective steps must be taken by appropriate government agencies to keep the existing districts in production as long as possible. Because this problem is regional in nature, officials of the various planning agencies throughout the region should work together toward coordinated solutions that insure a long term supply of aggregate from the existing districts, without compromising environmental or land use considerations.

During the course of the study, it was recognized that large areas of potential aggregate resource land existed within the study area that were not controlled by any aggregate producer. If proven to be of aggregate quality, these lands could be added to greater Los Angeles' list of aggregate reserves, thereby extending the total aggregate producing capacity of the region by a large, but presently undetermined, factor. These yet unproven potential reserves should be evaluated and inventoried as a natural continuation of the present study. Upon receipt of this

information, land use planning should be exercised that would (1) include proper zoning of these additional sources of aggregate for future extraction and (2) provide a reasonably prompt process of approval of permits for their extraction.

Allowance for proper geologic and geophysical methods of exploration and testing of new deposits must be taken into account. Geologic factors will play an important role in the development of new sources of aggregate to meet future demands. Existing high quality deposits are rapidly being depleted. Locating suitable replacement deposits and assuring the quality of these potential new supplies for aggregate use will require geologic exploration including mapping, trenching, and extensive laboratory testing. Geology-related factors such as type and proportion of waste in each deposit, ground-water impacts, and particle size grading will have to be assessed.

Lastly, industry-supportive local government policies that will encourage the capital investment necessary for the development of economical aggregate-processing operations must be provided. Producers would then be able to make provisions for acquiring these nearby sources of new reserves that can be phased into production in an orderly and economical manner as existing reserves are being depleted.

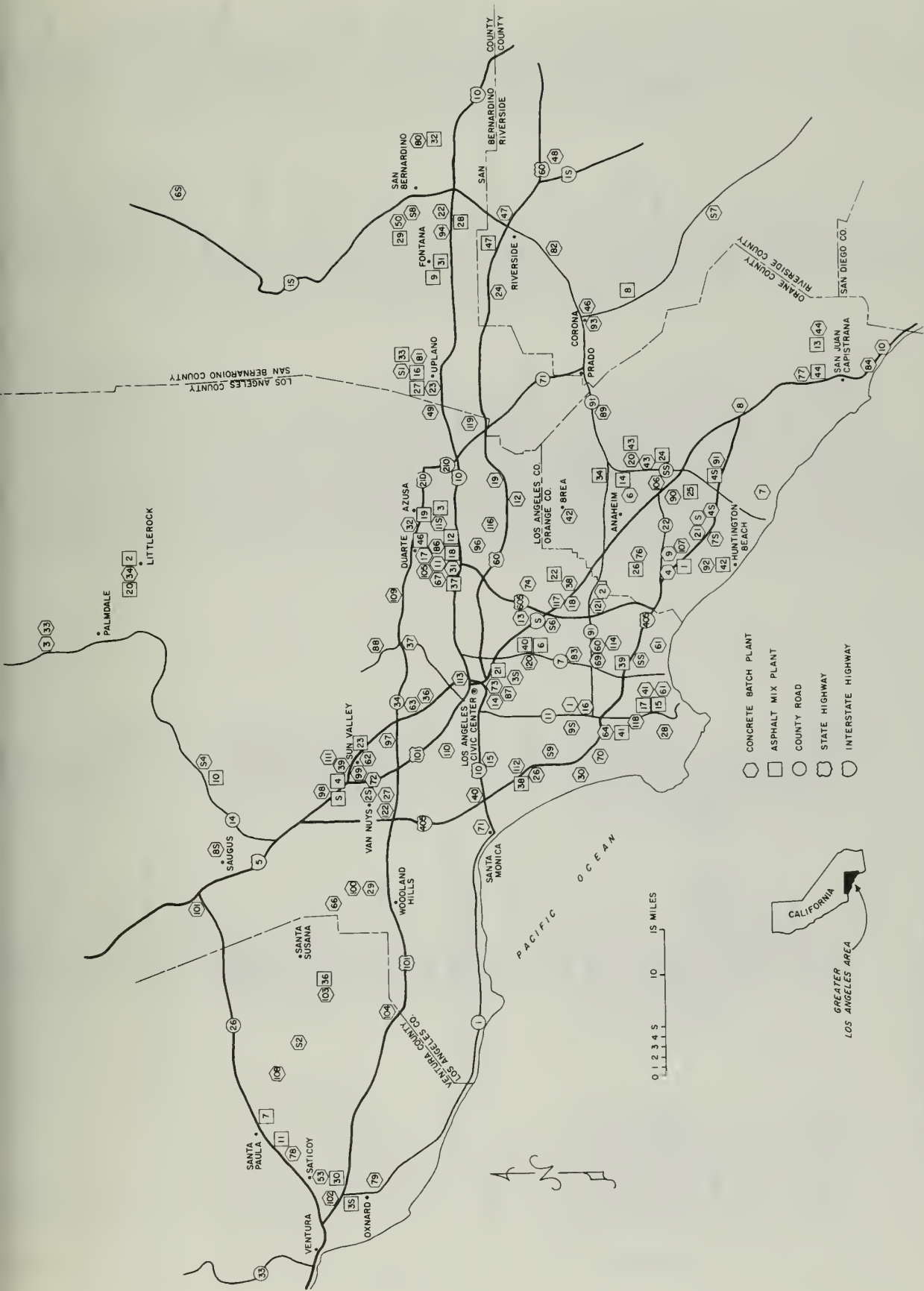
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APPENDIX I



Portland cement, concrete batch plants and asphaltic concrete batch plants in the greater Los Angeles area.

LOS ANGELES BASIN AGGREGATES CONCRETE BATCH PLANTS (continued)

MAP NO.	PLANT	LOCATION	COUNTY
111	Transit Mixed Concrete	Sun Valley	Los Angeles
112	Transit Mixed Concrete	Inglewood	Los Angeles
113	Transit Mixed Concrete	Los Angeles	Los Angeles
114	Transit Mixed Concrete	Long Beach	Los Angeles
115	Transit Mixed Concrete	Azusa	Los Angeles
116	Transit Mixed Concrete	Industry	Los Angeles
117	Transit Mixed Concrete	Santa Fe Springs	Los Angeles
118	Transit Mixed Concrete	Torrance	Los Angeles
119	Transit Mixed Concrete	Pomona	Los Angeles
120	United Ready Mix	South Gate	Los Angeles
121	United Ready Mix	Artesia	Los Angeles
122	Wagnild Ready Mix	Van Nuys	Los Angeles

LOS ANGELES BASIN AGGREGATES ASPHALT MIX PLANTS

MAP NO.	PLANT	LOCATION	COUNTY
1	All America Asphalt	Westminster	Orange
2	Asphalt Cons. Co.	Little Rock	Los Angeles
3	Associated Asphalt	Azusa	Los Angeles
4	Blacktop Materials	Sun Valley	Los Angeles
5	Blacktop Materials	Sun Valley	Los Angeles
8	Blue Diamond	South Gate	Los Angeles
7	Curtis-Hooker	Santa Paula	Ventura
8	Fontana Paving	Corona	Riverside
9	Fontana Paving	Fontana	San Bernardino
10	Gillibrand, P. W.	Soledad Canyon	Los Angeles

11	Gillibrand, P. W.	Santa Paula	Ventura
12	Griffith	Irwindale	Los Angeles
13	Griffith	San Juan Capistrano	Orange
14	Griffith	Santa Ana Canyon	Orange
15	Griffith	Wilmington	Los Angeles
16	Holiday Rock	Upland	San Bernardino
17	Industrial Asphalt	Carson	Los Angeles
18	Industrial Asphalt	Irwindale	Los Angeles
19	Industrial Asphalt	Irwindale	Los Angeles
20	Industrial Asphalt	Little Rock	Los Angeles
21	Industrial Asphalt	Los Angeles	Los Angeles
22	Industrial Asphalt	Santa Fe Springs	Los Angeles
23	Industrial Asphalt	Sun Valley	Los Angeles
24	Industrial Asphalt	Orange	Orange
25	Industrial Asphalt	Santa Ana	Orange
26	Industrial Asphalt	Stanton	Orange
27	Industrial Asphalt	Montclair	San Bernardino
28	Industrial Asphalt	Rialto	San Bernardino
29	Industrial Asphalt	San Bernardino	San Bernardino
30	Industrial Asphalt	Saticoy	Ventura
31	Inland Asphalt	Fontana	San Bernardino
32	Match	Redlands	San Bernardino
33	Matich	Upland	San Bernardino
34	Noble, R. J.	Orange	Orange
35	Southern Pacific Milling	Oxnard	Orange
36	Southern Pacific Milling	Simi	Ventura
37	Sully-Miller	El Monte	Los Angeles
38	Sully-Miller	Inglewood	Los Angeles
39	Sully-Miller	Long Beach	Los Angeles
40	Sully-Miller	South Gate	Los Angeles
41	Sully-Miller	Torrance	Los Angeles
42	Sully-Miller	Huntington Beach	Orange
43	Sully-Miller	Orange	Orange
44	Sully-Miller	San Juan Capistrano	Orange
45	Sully-Miller	Irvine	Orange
46	Vernon Asphalt Materi- als	Irwindale	Los Angeles
47	Yeager Cons. Co.	Riverside	Riverside

APPENDIX II

Guidelines for Examination of Aggregate Operations

- I. GENERAL DATA
 - A. Name of deposit and/or plant
 - B. Location
 - C. Company management and/or field staff
 - D. CDMG Investigator
 - E. Date of field and/or office visit
 - F. Sources of data
- II. OWNERSHIP DATA
 - A. Fee land
 1. Ownership
 2. Amount
 3. How long held
 4. Map showing location
 - B. Leased Land
 1. Ownership
 2. Amount
 3. How long held
 4. Map showing location
 5. Royalty paid
 - a. To whom
 - b. For how long
 - c. Rate per ton
 - d. Total \$ per year paid
- III. HISTORY OF OPERATION, PRODUCTION, AND MARKETING DATA
 - A. Date of first extraction
 1. Operations; continuous, discontinuous, since inception
 2. Reasons for discontinuation of operation
 - B. Production
 1. Total production by year
 2. By product sold
 - a. Concrete aggregates
 - b. Asphaltic concrete aggregates
 - c. Base materials
 - d. Fill
 - e. Other
 3. Rate of yearly production
 - a. Average past 10 years
 - b. Maximum possible production
 - c. Years of deposit life left
 - C. Pitside (f.o.b.) prices per ton for each product sold
 - D. Imports-exports across county lines
 1. Amount
 - a. Type of material
 - b. From where and to where
 - c. For how long
 - d. Costs
 - E. Transportation
 1. Types used
 2. Company vs contract hauling
 3. Costs
 - a. PUC rates if applicable
 1. Production areas and numbers
 2. Delivery zones and numbers
 4. Miscellaneous related transportation costs such as loading and unloading
 - F. Location and ownership of concrete batch and asphaltic batch plants

GEOLOGY AND QUALITY CONTROL

- A. Geological formation, member, or unit
 1. Name
 2. Age/fossils, etc.
 3. Areal distribution
 4. Type area or section
- B. Geological contact relations
 1. Relation to adjacent rock units
 2. Nature and type of geological contacts
 3. Facies changes
- C. Type of deposit
 1. Origin
 - a. Floodplain, alluvial fan, stream channel, stream terrace, talus, dredge tailings, mine tailings, bedrock, marine terrace, glacial, beach, offshore marine, sand dune
 2. Conditions of deposition
 3. Source areas
 4. Shape of basin of deposition
 5. Paths of material into basin
- D. Topographic expression
 1. Type of topographic expression
 - a. Hills, bluffs rolling, etc.
 2. Relief and natural slope angle
 3. Drainage; type and style
 4. Quality and amount of exposure
 5. Weathering features
 6. Erosional features
 7. Vegetation type and amount
- E. Bulk properties
 1. Overall attitude and variations in attitude of bedding
 2. Thickness of deposit, length, and variations in general shape; wedge, lens, etc.
 3. Structural deformation; faulted, folded, etc.
 4. Small scale structures
 - a. Primary; such as stratification, cross-bedding, ripple marks, scour, etc.
 - b. Secondary; such as fissility, fracture, joints, concretions, nodules, disrupted bedding, slump, clastic dikes, etc.
 - c. Describe form, color, dimensions, development, distribution, orientation, boundary conditions, style
 5. Porosity
 - a. % pore space
 6. Permeability; high, intermediate, low
 7. Specific gravity
 8. Weight per cubic foot; average, variations in
- F. Lithology of deposit
 1. Color
 - a. Fresh and weathered surfaces
 - b. Distribution
 2. Induration
 - a. How well indurated
 - b. Cementing agent
 3. Texture
 - a. Grading; grain size, average and range
 - b. Sorting
 1. Amount by volume of coarse fraction – pebble, cobble and boulder
 2. Amount by volume of fine fraction – granule and smaller; specify clay fraction
 3. Ratio coarse to fine fraction
 - c. Sphericity of fragments
 - d. Roundness of fragments
 - e. Surface luster and relief of fragments
 4. Composition
 - a. Minerals; types and amount

- b. Rocks; types and amount
- c. Organic matter and/or encrustations
- d. Alteration products of minerals/rocks
- e. Rock classification

G. Quality control for processed material

- 1. Aggregate test results
 - a. Mechanical analysis
 - b. Los Angeles abrasion
 - c. Petrographic analysis
 - d. Specific gravity and absorption of coarse and fine materials
 - e. Unit weight
 - f. Sand equivalent
 - g. Durability
 - h. Cleanness
 - i. Soundness
 - j. Percent crushed particles
 - k. Organic impurities
 - l. Compaction
 - m. Alkali reactivity
 - n. Etc.
- 2. Reactive rocks or materials
- 3. Specifications required; by who

V. RESERVES AND RESOURCES

- A. Tonnage and how determined; separate in-the-ground, from recoverable, give tonnage under plant site separately
 - give tonnage factor and how determined
 - 1. Property lines with plots of extraction areas
 - 2. Setbacks
 - 3. Pit slope requirements
 - 4. Maximum pit depth permitted
 - 5. Present pit configuration
 - 6. Nature of pit bottom
 - 7. Position and variation in ground water surface
 - 8. Amount of overburden, average thickness, and variation in
 - 9. % of waste during mining and after stripping
 - 10. Amount of remaining, and how distributed

VI. EXTRACTION AND PROCESSING

- A. Extraction methodology and character of extraction area
 - 1. Type of mining operation
 - 2. Equipment used in mining
 - 3. Describe extraction area, present and ultimate size
 - 4. Stripping ratio (tons/tons)
- B. Processing plant
 - 1. Flowsheet
 - 2. Rated capacity
 - 3. Days and hours of operation
 - 4. Production costs (per ton of material)
- C. Roads; in and out
- D. Access to freeways or railroads

VII. LAND AND WATER USE

- A. Zoning restriction and code numbers
- B. Land use permits and code numbers (attach to report)
- C. Land reclamation plans, costs and related problems
 - 1. Ultimate uses of reclaimed land
 - a. Appropriate maps and sketches
- D. Stripping waste and tailings disposal
 - 1. Amount

2. Where
3. Storage
4. Compacted or loose
5. Problems related to
- E. Water use
 1. Source; location
 2. Amount
 3. Costs
- F. Waste water disposal
 1. Settling basins
 - a. Number
 - b. Size
 - c. Amount of water reused
 2. Other methods of waste water disposal
 - a. Amount
 - b. Manner
 - c. Type
 3. Waste water discharge requirements (attach to report)

III. ENVIRONMENTAL CONSIDERATIONS

- A. Noise and vibration control
- B. Air pollution control
- C. Dust control
- D. Setbacks
- E. Slopes
- F. Fencing
- G. Hours of legal operation
- H. Insurance
 - I. Main highways or freeways used
- J. In and out roads and traffic safety
- K. Off street parking
- L. Signs posted
- M. Beautification
 1. Appearance
 2. Screening effect

IX. ECONOMIC DATA

- A. Employees totals
 1. Mining and processing
 2. Supervision and administration
 3. Total annual payroll
- B. Taxes paid
 1. County
 2. City
 3. State
 4. Federal
- C. Place in local economy
- D. Current assessed valuation of buildings and equipment

X. CONCLUSIONS AND/OR RECOMMENDATIONS

XI. REFERENCES

XII. ATTACHMENTS

- A. Maps
- B. Flowsheets
- C. Photographs
- D. Tables
- E. Published articles

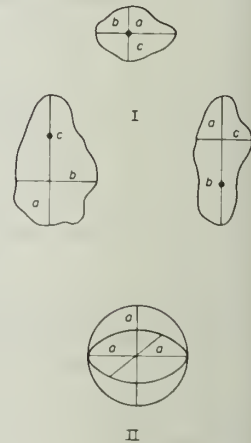
XIII. GENERAL LAND USE AND ECONOMIC DATA

- A. Maps showing area zoned for aggregate extraction
- B. Requirements for zoning, operating and safety ordinances for county or city
- C. Brief history of zoning and permit problems 1960 to present
- D. Population figures 1960 to present and projected to 1990; also population growth rate (by county or city)
- E. Total values of building permits, engineered construction, and total construction 1960 to present in current dollar value
- F. Area growth maps
- G. Other significant information

SHAPE AND SIZING OF GRAINS

NATIONAL RESEARCH COUNCIL			WENTWORTH		
Classification	Size	mm in	Classification	Size	mm in
	4096				
Very large boulders	161.3				
	2048				
Large boulders	80.63				
	1024				
Medium boulders	40.31				
	512				
	20.16				
Small boulders	256				
	10.08				
Large cobbles	128				
	5.04				
Small cobbles	64				
	2.52				
Very coarse gravel	32				
	1.26				
Coarse gravel	16				
	0.630				
Medium gravel	8				
	0.315				
Fine gravel	4				
(No. 5)	0.157				
Very fine gravel	2				
(No. 10)	0.079				
Very coarse sand	1				
(No. 16)	0.0394				
Coarse sand	0.50				
(No. 30)	0.0197				
Medium sand	0.25				
(No. 60)	0.0098				
Fine sand	0.125				
(No. 120)	0.0049				
Very fine sand	0.0625				
(No. 250)	0.0025				
Coarse silt	0.0313				
	0.0013				
Medium silt	0.0156				
	0.00062				
Fine silt	0.0078				
	0.00031				
Very fine silt	0.0039				
	0.00015				
Coarse clay size	0.00015				
	0.00195				
Medium clay size	0.000077				
	0.00098				
Fine clay size	0.000038				
	0.00049				
Very fine clay size	0.000019				
	0.00024				
	0.0000096				
(Numbers in parenthesis above are U. S. Standard sieve sizes.)					
Type	Geometric		Geometric		
	1"		2"		

Figure 2. (I), Sketches of irregularly shaped particle showing the a, b, and c diameters. (II), Sketch of spherical particle with equidimensional diameters. Most irregularly shaped grains can be assigned three distinct diameters (a, long; b, intermediate; c, short) of different lengths; in a sphere all diameters are equal.



For exacting studies there is a problem of just how to represent the grain size of a sediment. The size of irregular grains can be expressed by computation of a nominal diameter (diameter of a sphere that has the same volume as the particle; computed as the cube root of 1.92 times the volume of the particle measured in cubic centimeters). For example, if the irregular grain in I were of the same volume as the sphere in II, and made of a plastic material that could be moulded into the shape of the sphere, the size could be expressed as the length of the diameter of the sphere (a). Of course grains are not plastic, and it is necessary to compute the volume of an irregular particle in other ways, such as measuring the water displaced in a graduated cylinder when the particle is dropped in it, and then applying the previously given formula. It is much easier and nearly as accurate to use either of two other diameter (size) measurements. These are the mean diameter $\frac{a+b+c}{3}$ or the intermediate diameter (b).

Tyler Standard (2)*			Am. Soc. for Testing Materials, U.S. Series (3)*		
Mm.	Inches	Mesh no.	Mm.	Inches	
6.68	0.263	3	6.35	0.250	
4.70	0.185	4	4.76	0.187	
3.96	0.156	5	4.00	0.157	
3.33	0.131	6	3.36	0.132	
2.79	0.110	7	2.83	0.111	
2.36	0.093	8	2.38	0.0937	
1.98	0.078	10	2.00	0.0787	
1.65	0.065	12	1.68	0.0661	
1.40	0.055	14	1.41	0.0555	
1.17	0.046	16	1.19	0.0469	
0.991	0.0390	18	1.000	0.0394	
0.833	0.0328	20	0.840	0.0331	
0.701	0.0276	25	0.710	0.0280	
0.589	0.0232	30	0.590	0.0232	
0.495	0.0195	35	0.500	0.0197	
0.417	0.0164	40	0.420	0.0165	
0.351	0.0138	45	0.350	0.0138	
0.295	0.0116	50	0.297	0.0117	
0.246	0.0097	60	0.250	0.0098	
0.208	0.0082	70	0.210	0.0083	
0.175	0.0069	80	0.177	0.0070	
0.147	0.0058	100	0.149	0.0059	
0.124	0.0049	120	0.125	0.0049	
0.104	0.0041	140	0.105	0.0041	
0.088	0.0035	170	0.088	0.0035	
0.074	0.0029	200	0.074	0.0029	
0.060	0.0024	230	0.062	0.0024	
0.053	0.0021	270	0.053	0.0021	
0.043	0.0017	325	0.044	0.0017	
0.038	0.0015	400	0.037	0.0015	

Taken from Mineral Information Service, v. 13, no. 9, 1960 -- Grain Size of Fragmental Rocks by James R. Evans

APPENDIX III

STATE OF CALIFORNIA — THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGYMINERAL PROPERTY and/or
MILL AND PROCESSING PLANT REPORT ★

Name of property, mill, or plant... CONROCK COMPANY - RELIANCE
 Commodity... SAND & GRAVEL
 County... LOS ANGELES
 Township... 1 N Range... 10 W Section... 4, 28, 32, 33
 Latitude... 34° 07' 30" N Longitude... 117° 56' 15" W
 S.G.S. quad... BALDWIN PARK AND AZUSA 7 1/2'

C.D.M.G. Investigator... Thomas P. Anderson
 Date of field visit... February 11, 1976
 Date of office data review...
 Date approved...

Location, Accessibility, and Physiography:

The Reliance pits and plant are on an alluvial fan that can be traced to the mouth of the San Gabriel River about 4 miles to the northeast (attachment 1). The crushing and screening plant is located north of the intersection of Irwindale Avenue and Foothill Boulevard 2 miles north of Irwindale. Foothill Freeway (Interstate 210) and the Metcheson Topeka and Santa Fe railroads border the property to the north and south (attachment 2).

Ownership, Leaseholders, Intermediaries:

Conrock Company owns 293 acres of fee held land. Their corporate headquarters is at 200 San Fernando Road, Los Angeles, California 90051 (telephone 213-258-2777). The Reliance plant is under the supervision of Mr. Cam Rose, general superintendent for Conrock. His office is located at the plant site on 16001 Foothill Boulevard in Irwindale, California 91700 (telephone 213-442-3304).

History, Production, and Marketing. (trade names, and availability of milled and/or processed products):

Property in the area was acquired by the Reliance Rock Company in 1924. In 1929, they were absorbed in Consolidated Rock Product Company, predecessor to Conrock Company. In 1972, the Company had constructed one of the most modern plants in the world for handling aggregate to replace the original plant which was built in 1918. The rated capacity of the new plant is 12 - 1,400 tons per hour. Material is transported by conveyor from pit B located about 0.5 mile southwest of the washing and screening plant (attachment 3). Since the new plant has been in operation it has yielded an average of 2,350,000 tons of aggregate per year. The processed material is shipped mostly by truck and a minor amount by unit-train. Material moving by rail is shipped to Santa Barbara. Approximately 65% of truck hauling is with company owned vehicles while the remainder is transported by contractors at rates established by the Public Utilities Commission (attachment 4). Under present conditions aggregate can be moved from Irwindale into the surrounding local and Los Angeles Civic Center at a lower cost than material originating from any other area.

* Attach index, claim, geologic maps, sketches, photos, assay results, production data, smelter shipments, other reports or important data of any kind.

The Company produces a number of products from their operation. These include:

Washed concrete sand	#8 pan dust	1 1/2 B-CL, 30C base
Washed plaster sand	1/4" x #8 crushed rock	1 1/2 B-CL, 2ST base
3/8" x #8 gravel	3/8" x #8 crushed rock	3/4 B-CL, 2ST base
1" x #3 gravel	1/2" x #3 crushed rock	3/4" crushed aggregate base
1 1/2" x 3/4" gravel	3/4" x #3 crushed rock	Ballast
#3 x #200 unwashed sand	1" x 1 1/2" crushed rock	

Material from the plant is sold at open rate schedule (attachment 3). Industrial As Company operates a batch plant located adjacent to the Reliance plant that is capable producing about 500 tons per hour of finished product. It is estimated that the end distribution of production is: 40% Concrete Aggregates, 20% Asphaltic Concrete aggregate, 30% Base Materials, and 10% Fill.

Mill and/or Plant Flowsheet (describe source and location of raw material):

The Conrock plant at Reliance is an extremely modern, highly automated operation with a rated capacity of 1,200-1,400 tons per hour (attachment 6). Material moves through a typical wet and dry circuit at the plant. Its highly automated design and attendant flexibility is capable of turning out 18 different products with short notice and can blend material to suit a particular set of specifications (attachment 7).

Geology and Mineralogy:

The Reliance property is on an alluvial fan that can be traced for about 4 miles to the northeast to the San Gabriel Mountains. The fan at the base of the San Gabriel Mountains is around 2,000' wide, while further south, it spreads to a width of approximately 4 miles. It is bounded to the west by Rio Hondo Wash and on the east by Dalton Wash (attachment 8).

The local topography slopes to the southwest with a change from 620' in elevation to 500' at its southern extremity. This represents a gradient of 120' per mile. Drainage is mostly subsurface due to the high porosity (estimated at 20%) and permeability of the fan. Sand and gravel are well exposed over most of the area. The material is Holocene in age and appears light brown when dry and dark brown when wet. The depth of the aggregate extends to at least 330' beneath the property. Based upon subsurface data from nearby areas, it is quite likely that this depth goes to at least 500'.

The deposit is flat lying and poorly sorted with sand lenses a few inches thick distributed in places. It is estimated that 40% of the deposit is composed of pebbles, cobbles and boulders. These are present in about equal proportions. Boulders are often quite large with some measuring in excess of 8'. They tend to be more spheroidal than smaller size material that are often present as bladed to sub-rounded forms. The matrix material ranges from silt to coarse sand with subangular coarse sand being dominant.

The aggregate for the most part is very hard and durable. Exceptions to this include biotite and hornblende rich rocks. These make up about 2% of the coarse fraction. Types that have been recognized in the deposit include: granitic, granodiorite, felsic schists and granite gneiss.

Mining:

Extraction of sand and gravel is from an excavation measuring approximately 1,000 x 1,000 feet laterally and with a depth of 150'. The operation is conducted on a 5 day per week

th a single shift devoted to production. A model 997 American 4 year Bank drag util-
ing a 3,000 # scraper removes material from the side of the pit. A 190-B Bucyrus Erie
1/2 cubic yard shovel picks the material up from the base of the pit and dumps it into
portable shovel hopper (attachment 6, 7, 9) where the material is then fed into 72"
ndulum conveyor. The material is passed onto a 60" x 16' Simplicity vibrating grizzly
eder. Oversize material is fed into a 48" x 60" jaw crusher where it is reduced to
nus 8" size. The crushed rock and fines then move on a 42" conveyor belt for a distance
approximately 2,700' to a surge pile at the processing facility.

Reclamation:

ere are no reclamation plans for the Reliance pits at this time. A number of plans
or this are presently under review by the Company.

Environmental Consideration—such as zoning restrictions and problems, land
se permits, air and sound factors, water use and water quality problems:

he Company is required by their use permit to have set backs of 100' (attachment 10)
d maintain pit sides at no greater than a 1:1 slope. Operations are from 6:00 a.m.
o 10:00 p.m. (attachment 11).

ust control is maintained by utilizing a Johnson-Marsh Chem-Jet system at their
ushing facilities.

ater for the operation comes from a Company owned well located on the property which
upplies about 2,500 gallons of water a minute to the plant. The discharge water from
rocessing is poured into a settling pond where the fines settle and the water seepes
nderground for reuse.

he Company provides off-street parking. They have a 6' chain link fence surrounding
he property which is posted with signs prohibiting unauthorized entry. Beautification
ncludes block wall and flowered planting around the property.

Conclusions and/or Recommendations:

he Reliance plant of Conrock Company is very modern and efficient. At the present rate
of production it is anticipated that a sustained output of aggregate can be maintained
for the next couple of decades and substantially longer if resources beneath the present
imits of extraction are made available for extraction.

The Company has shown a concern for its working environment by taking measures to
minimize adverse effects of mining through planting trees and maintaining dust control.

References:

- (1) California Journal of Mines and Geology, 1954, v. 50
- (2) Rock Products, June 1973
- (3) Pit and Quarry, September 1973

Attachments:

- (1) Topographic map showing Reliance property
- (2) Property map showing boundaries, freeway and railroad
- (3) Plan showing location of present mining operations and processing facility
- (4) PUC rate schedule
- (5) Conrock products rate schedule
- (6) Plan sheet for Reliance plant
- (7) Geologic map of San Gabriel Valley

APPENDIX IV

STANDARD SPECIFICATIONS FOR CONCRETE
AGGREGATES, ASPHALT CONCRETE, AGGREGATE
SUBBASES AND AGGREGATE BASES

taken from:
Standard Specifications
California Department of
Transportation
January 1975, 620 p.

the atomic absorption method. The instrument and procedure used shall be qualified as to precision and accuracy in accordance with the requirements of ASTM Designation: C 114.

- (2) The cement shall meet the requirements for compressive strength. The tensile strength shall not apply.
- (3) The autoclave expansion shall not exceed 0.50 percent.
- (4) Mortar, containing the portland cement to be used and Ottawa sand, when tested in accordance with Test Method No. Calif. 527, shall not expand in water more than 0.010 percent and shall not contract in air more than 0.048 percent.

Type III and Type V portland cements shall conform to the specifications in ASTM Designation: C 150, and the modifications listed above for Type II Modified cement except that when tested in accordance with Test Method No. Calif. 527, mortar containing Type III portland cement shall not contract in air more than 0.075 percent.

Portland cement used for precast prestressed concrete piling and precast prestressed concrete members will be designated as "Type II Prestress" and shall conform to the requirements for Type II Modified except that the mortar when tested in accordance with Test Method No. Calif. 527, shall not contract in air more than 0.053 percent.

Either Type II Prestress or Type II Modified cement may be used in steam-cured concrete products.

All cement used in the manufacture of cast-in-place concrete for exposed surfaces of like elements of a structure shall be of the same brand.

The cement shall be protected from exposure to moisture until used. Sacked cement shall be so piled as to permit access for tally, inspection, and identification of each shipment.

The Contractor shall make arrangements with the manufacturer of ready-mixed concrete, or precast concrete products, to provide adequate facilities to assure that cement meeting the requirements specified in this Section, 90-2.01 will be kept separate from other cement in order to prevent any but the specified cement entering the work. The Contractor shall also make arrangements with said manufacturer to provide safe and suitable facilities for sampling cement at the weighing hopper, or in the feed line immediately before entering the hopper.

If cement is used prior to sampling and testing as provided in Section 6-1.07, "Certificates of Compliance," and the cement is delivered directly to the site of the work, the Certificate of Compliance shall be signed by the cement manufacturer. If the cement is used in ready-mixed concrete or in precast concrete products purchased as such by the Contractor, the Certificate of Compliance shall be signed by the manufacturer of such concrete or product.

Cement furnished without a Certificate of Compliance shall not be used in the work until the Engineer has had sufficient time to make appropriate tests and has approved the cement for use.

90-2.02 Aggregates—Aggregates shall be free from deleterious coatings, clay balls, roots, bark, sticks, rags and other extraneous material.

All natural aggregates shall be thoroughly and uniformly washed before use. Aggregates will be sampled at the discharge gates of the bins feeding the weigh hopper. The Contractor, at his expense, shall provide safe and suitable facilities for obtaining the samples.

Aggregates shall be of such character that it will be possible to produce workable concrete within the limits of water content provided in Section 90-6.06, "Amount of Water and Penetration."

PORTLAND CEMENT CONCRETE

SECTION 90

90-1 GENERAL

90-1.01 Description—Portland cement concrete shall be composed of portland cement, fine aggregate, coarse aggregate, admixtures if used, and water, proportioned and mixed as specified in these specifications.

Concrete will be designated by Class, cement factor in pounds per cubic yard, or by 28-day compressive strength or as minor concrete.

Class A concrete shall contain a minimum of 564 pounds of portland cement per cubic yard.

Class B concrete shall contain a minimum of 470 pounds of portland cement per cubic yard.

Class C concrete shall contain a minimum of 376 pounds of portland cement per cubic yard.

Class D concrete shall contain a minimum of 658 pounds of portland cement per cubic yard.

Whenever the 28-day compressive strength shown on the plans is 3,500 pounds per square inch or greater, the concrete shall be considered to be designated by compressive strength. The 28-day compressive strengths shown on the plans which are less than 3,500 pounds per square inch, are shown for design information only and are not to be considered a requirement for acceptance of the concrete.

When concrete is designated by compressive strength, the mix proportions shall be determined so that the concrete will contain not less than 564 pounds and not more than 800 pounds of cement per cubic yard except that concrete used in roadway deck slabs and slab spans for highway bridges shall contain not less than 658 pounds of cement per cubic yard. The proportions shall be such that the concrete will conform to the strength shown on the plans or specified in the special provisions.

The Contractor shall determine the mix proportions for all concrete to be used in concrete structures. The Engineer will determine the mix proportions for all other concrete.

Before using concrete for which the mix proportions have been determined by the Contractor, or in advance of revising such mix proportions, the Contractor shall submit in writing to the Engineer a copy of the mix design.

Compliance with cement factor requirements will be verified in accordance with procedures described in Test Method No. Calif. 518. Batch proportions shall be adjusted as necessary to produce concrete having the specified cement factor.

All concrete for which the mix proportions are determined either by the Contractor or the Engineer shall conform to the requirements of this Section 90.

90-2 MATERIALS

90-2.01 Portland Cement—Unless otherwise specified, portland cement for all concrete construction, except precast prestressed concrete piling and precast prestressed concrete members, will be designated as "Type II Modified" and shall be Type II cement conforming to the specifications of ASTM Designation: C 150, with the following modifications:

- (1) The cement shall not contain more than 0.60 percent by weight of alkalis, calculated as the percentage of Na_2O plus 0.658 times the percentage of K_2O , when determined by either direct intensity flame photometry or by

Aggregates shall have not more than 10 percent loss when tested for soundness in accordance with Test Method No. Calif. 214.
The soundness requirement for fine aggregate will be waived, provided that the durability index, D_r , of the fine aggregate is 60, or greater, when determined by Test Method No. Calif. 229.

Aggregates specified for freeze-thaw resistance shall pass the freezing and thawing test, Test Method No. Calif. 528.

The Contractor shall notify the Engineer of the proposed source of freeze-thaw resistant concrete aggregates at least 4 months before intended use. Should the Contractor later propose a different source of concrete aggregates, he shall again notify the Engineer at least 4 months before intended use. Blending of fine or coarse aggregates from untested sources with acceptable aggregates will not be permitted. Provisions for the time of submission of samples as provided in Section 40-1.01, "Description," are superseded by the foregoing.

Concurrently with notification of proposed sources of freeze-thaw resistant concrete aggregates, the Contractor shall furnish samples in the quantity ordered by the Engineer. The samples shall be secured under the direct supervision of the Engineer. Samples from existing stockpiles of processed aggregate shall be taken from washed materials and shall be visibly damp. Samples from materials in place in a material source shall be taken at depths from the existing surface that will insure the presence of the full quantity of ground water. Excavations for the purpose of securing samples shall be made to the full depth of intended source operations. Samples shall be protected against loss of contained water until they are delivered to the Engineer.

The Engineer will waive the above freeze-thaw test and the 4-month advance notice, required in this section, provided aggregates are to be obtained from sources that have previously passed this test and test results are currently applicable.

No extension of contract time will be allowed for the time required to perform said freezing and thawing test.

90-2.02A Coarse Aggregate.—Coarse aggregate shall consist of gravel, crushed gravel, crushed rock, crushed air-cooled iron blast furnace slag, or combinations thereof. Crushed air-cooled iron blast furnace slag shall not be used in any precast or prestressed portland cement concrete component or structure, or reinforced portland cement concrete.

Coarse aggregate shall conform to the following quality requirements:

Tests		Test Method	Requirements
Loss in Los Angeles Rattler (after 500 revolutions)		No. Calif. 211	45% Max.
Cleanliness Value		211	
Individual Test Result		227	71 Min.
Moving Average			76 Min.

Evaluation of test results, with moving averages specified, shall conform to the provisions in Section 6-3.02, "Statistical Testing."

90-2.02B Fine Aggregate.—Fine aggregate shall conform to the following quality requirements:

Tests		Test Method	Requirements
Organic Impurities		No. Calif. 213	Satisfactory ¹
Mortar Strengths Relative to Ottawa Sand		515	95% Min.
Sand Equivalent		217	
Individual Test Result			71 Min.
Moving Average			76 Min.

¹ Fine aggregate developing a color darker than the reference standard color solution may be accepted if it is determined by the Engineer, from mortar strength tests, that a darker color is acceptable.

Evaluation of test results, with moving averages specified, shall conform to the provisions in Section 6-3.02, "Statistical Testing."

90-2.03 Water.—In conventionally reinforced concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than 1,000 parts per million of chlorides as Cl, nor more than 1,300 parts per million of sulfates as SO_4 . In prestressed concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than 650 parts per million of chlorides as Cl, nor more than 1,300 parts per million of sulfates as SO_4 . In no case shall the water contain an amount of impurities that will cause a change in the setting time of portland cement of more than 25 percent nor a reduction in the compressive strength of mortar at 14 days of more than 5 percent when compared to the results obtained with distilled water.

In non-reinforced concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than 2,000 parts per million of chlorides as Cl, nor more than 1,500 parts per million of sulfates as SO_4 .

In addition to the above requirements, water for curing concrete shall not contain any impurities in a sufficient amount to cause discoloration of the concrete or produce etching of the surface.

90-3 AGGREGATE GRADINGS

90-3.01 General.—The grading of all concrete aggregates will be determined by Test Method No. Calif. 202.

Evaluation of test results, with moving averages specified, shall conform to the provisions in Section 6-3.02, "Statistical Testing."

Before beginning concrete work, the Contractor shall submit in writing to the Engineer the gradation of the primary aggregate nominal sizes which he proposes to furnish. If a primary coarse aggregate or the fine aggregate is separated into 2 or more sizes, the proposed gradation shall consist of the gradation for each individual size, and the proposed proportions of each individual size, combined mathematically to indicate one proposed gradation. Such gradation shall meet the grading requirements shown in the table in this section, and shall show the percentage passing each of the specified sieve sizes.

Gradations proposed by the Contractor shall be within the following limits:

Primary Aggregate	Nominal Size	Sieve Size	Limits of Proposed Gradation
$2\frac{1}{2}" \times 1\frac{1}{2}"$		2"	49-56
$1\frac{1}{2}" \times \frac{3}{4}"$		1"	19-41
$1" \times \text{No. 4}$		$\frac{3}{4}"$	52-88
$1" \times \text{No. 4}$		$\frac{3}{8}"$	12-38
Fine Aggregate		No. 16	55-70
Fine Aggregate		No. 30	34-46
Fine Aggregate		No. 50	16-29

Should the Contractor change his source of supply, he shall submit in writing to the Engineer the new gradations before their intended use.

The Engineer may waive the furnishing of the gradation required in this Section 90-3.01 if, in his opinion, the furnishing of said gradation is not necessary for the type or amount of concrete work to be constructed. However, the Contractor will be required to furnish material conforming to the combined aggregate gradings provided in Section 90-3.04, "Combined Aggregate Gradings."

90-3.02 Coarse Aggregate Grading.—The grading requirements for coarse aggregates are shown in the following table for each size of coarse aggregate:

Sieve Sizes	Percentage Passing					
	Primary Aggregate			Nominal Sizes		
	2½" × 1½"		1½" × ¾"	1" × No. 4		Moving
	Individual	Average	Individual	Individual	Average	Average
Test Result	Test Result	Test Result	Test Result	Test Result	Test Result	Test Result
3"	100	100	—	—	—	—
2½"	88-100	91-100	—	—	—	—
2"	X±18	X±12	100	100	100	100
1½"	0-17	0-14	88-100	91-100	91-100	91-100
1"	—	—	X±18	X±12	X±18	X±12
¾"	0-7	0-4	0-17	0-14	X±18	X±12
¾"	—	—	0-7	0-4	X±18	X±12
No. 4	—	—	—	—	0-17	0-14
No. 8	—	—	—	—	0-7	0-4

In the above table, the symbol X is the gradation which the Contractor proposes to furnish for the specific sieve size as provided in Section 90-3.01, "General."

In addition to the above grading for the 1" × No. 4 primary aggregate nominal size, the distribution of the aggregate sizes shall be such that of the material passing the 3/4" sieve, not more than 50 percent of such material shall pass the 3/8" sieve.

Coarse aggregate for the 2 1/2" Max. and 1 1/2" Max. combined aggregate gradings as provided in Section 90-3.04, "Combined Aggregate Gradings," shall be furnished in 2 or more primary aggregate nominal sizes. Each primary aggregate nominal size may be separated into 2 sizes and stored separately provided that if the materials were combined they would conform to the grading requirements for that particular primary aggregate nominal size being separated.

When the 1" Max. combined aggregate grading as provided in Section 90-3.04, "Combined Aggregate Gradings," is to be used, the coarse aggregate may be separated into 2 sizes and stored separately provided that when combined the material shall conform to the grading requirements for the 1" × No. 4 primary aggregate nominal size.

The screen size to be used to separate any primary aggregate nominal size of coarse aggregate shall be selected by the Contractor. After separation, the coarse portion shall contain not more than 10 percent of material passing the separating screen and the fine portion shall contain not more than 10 percent of material retained on the separating screen.

90-3.03 Fine Aggregate Grading.—Fine aggregate shall be graded within the following limits:

Sieve Sizes	Percentage Passing	
	Individual	Moving
	Test Result	Average
¾"	100	100
No. 4	93-100	95-100
No. 8	61-99	66-94
No. 16	X±12	X±8
No. 30	X±11	X±7
No. 50	X±8	X±4
No. 100	1-12	3-9
No. 200	0-7	0-4

In the above table, the symbol X is the gradation which the Contractor proposes to furnish for the specific sieve size as provided in Section 90-3.01, "General."

In addition to the above required grading analysis, the distribution of the fine aggregate sizes shall be such that the difference between the total percentage passing the No. 16 sieve and the total percentage passing the No. 30 sieve shall be between 10 and 35, and the difference between the percentage passing the No. 30 and No. 50 sieves shall be between 10 and 30.

Fine aggregate may be separated into 2 or more sizes and stored separately, provided that when the materials are combined they will conform to the grading requirements specified in this Section 90-3.03.

90-3.04 Combined Aggregate Gradings.—Aggregates for each batch of concrete shall be combined in proportions that will produce a mixture within the grading limits for combined aggregates as specified in this Section 90-3.04. Within these limitations, the relative proportions shall be as ordered by the Engineer, except as otherwise provided in Section 90-1.01, "Description."

Grading Limits of Combined Aggregates

Sieve Sizes	Percentage Passing		
	2½" Max.	1½" Max.	1" Max.
	Test Result	Test Result	Test Result
3"	100	—	—
2½"	95-100	—	—
2"	80-95	100	—
1½"	63-87	90-100	100
1"	50-75	50-86	90-100
¾"	43-66	45-75	55-100
¾"	38-55	38-55	45-75
No. 4	30-45	30-45	35-60
No. 8	23-35	23-38	27-45
No. 16	17-27	17-33	20-35
No. 30	10-17	10-22	12-25
No. 50	4-9	4-10	5-15
No. 100	1-3	1-3	1-5
No. 200	0-2	0-2	0-2

The combined aggregate grading used in portland cement concrete pavement shall be either the 2 1/2" Max. grading or the 1 1/2" Max. grading at the option of the Contractor.

The combined aggregate grading used in concrete for structures and other concrete items, except when specified otherwise in these specifications or the special provisions, shall be either the 1 1/2" Max. grading or the 1" Max. grading at the option of the Contractor.

Changes from one grading to another shall not be made during the progress of the work unless permitted by the Engineer.

SECTION 39

ASPHALT CONCRETE

39-1 GENERAL

39-1.01 Description.—This work shall consist of furnishing and mixing aggregate and asphalt binder at a central mixing plant, and spreading and compacting the mixture, all as specified in these specifications and the special provisions.

Asphalt concrete is designated as Type A, Type B, Type C, or Open Graded. Asphalt concrete base is designated as Type A or Type B.

The type of asphalt concrete or asphalt concrete base will be shown on the plans or specified in the special provisions.

SECTION 39

ASPHALT CONCRETE

AGGREGATE GRADING REQUIREMENTS FOR ASPHALT CONCRETE

Percentage Passing

 $\frac{1}{2}$ " maximum

Sieve sizes	Coarse		Medium	
	Individual test result	Moving average	Individual test result	Moving average
1".....	100	100	100	100
$\frac{3}{4}$ ".....	87-100	90-100	90-100	95-100
$\frac{3}{8}$ ".....	55-80	60-75	60-85	65-80
No. 4.....	35-60	40-55	40-65	45-60
No. 8.....	22-45	27-40	25-50	30-45
No. 30.....	8-26	12-22	11-29	15-25
No. 200.....	0-8	3-6	0-9	3-7

 $\frac{1}{4}$ " maximum

Sieve sizes	Coarse		Medium	
	Individual test result	Moving average	Individual test result	Moving average
$\frac{1}{4}$ ".....	100	100	100	100
$\frac{1}{2}$ ".....	89-100	95-100	89-100	95-100
$\frac{3}{4}$ ".....	70-95	75-90	75-100	80-95
No. 4.....	45-72	50-67	50-77	55-72
No. 8.....	30-55	35-50	33-60	38-55
No. 30.....	10-34	15-30	14-38	18-33
No. 200.....	1-10	4-7	1-10	4-8

Sieve sizes	$\frac{3}{8}$ " maximum		No. 4 maximum	
	Individual test result	Moving average	Individual test result	Moving average
$\frac{1}{4}$ ".....	100	100	100	100
$\frac{1}{2}$ ".....	95-100	95-100	95-100	95-100
No. 4.....	65-85	70-80	70-80	70-80
No. 8.....	28-40	35-50	35-50	35-50
No. 30.....	7-14	7-16	7-16	7-16

39-2.03 Type A Aggregate.—Aggregate for Type A asphalt concrete shall consist of a mixture of coarse and fine aggregate, and a filler material if required, complying with the following requirements:

39-2.03A Coarse Aggregate.—Coarse aggregate shall consist of material of which at least 90 percent by weight shall be crushed particles.

39-2.03B Fine Aggregate.—Fine aggregate shall consist of material containing not less than 70 percent by weight of crushed particles in the portion passing the No. 4 sieve and retained on the No. 8 sieve.

39-2.03C Filler Material.—When the combined grading of the coarse and fine aggregates is deficient in material passing the No. 200 sieve, a commercial filler conforming to the requirements specified in this Section 39-2.03C shall be added as provided in Section 39-3.03, "Proportioning." The amount of commercial filler to be added shall be only that amount necessary to make the combined grading of the materials comply with the grading requirements for the completed mixture. In no case shall the amount of commercial filler added exceed 3 percent by weight of the combined aggregate.

39-2 MATERIALS

39-2.01 Asphalts.—Asphalt binder to be mixed with aggregate shall be liquid asphalt or paving asphalt as designated by the contract item. When there is no separate contract item for asphalt binder, paving asphalt shall be used unless liquid asphalt is specified in the special provisions.

Liquid asphalt to be mixed with aggregate shall conform to the provisions in Section 93, "Liquid Asphalts," and shall be of the grade designated by the contract item and shall be used as specified in these specifications.

Paving asphalt to be mixed with aggregate shall be a steam-refined asphalt conforming to the provisions in Section 92, "Asphalts," and shall be of the grade designated in the special provisions or as determined by the Engineer, and shall be used as specified in these specifications.

Liquid asphalt for prime coat shall conform to the provisions in Section 93, "Liquid Asphalts," and shall be of the grade designated by the contract item or specified in the special provisions and shall be applied as specified in these specifications.

Asphaltic emulsion for paint binder shall conform to the provisions in Section 94, "Asphaltic Emulsions," and shall be RS1 type or SS1 type as determined by the Engineer and shall be applied as specified in these specifications.

39-2.02 Aggregate.—Coarse and fine aggregates shall be clean and free from decomposed materials, vegetable matter and other deleterious substances.

Coarse aggregate is material retained on the No. 4 sieve and fine aggregate is material passing the No. 4 sieve.

The percentage of crushed particles will be determined by Test Method No. Calif. 205.

The combined aggregate, except that for asphalt concrete base and open-graded, shall conform to one of the gradings shown in the following table immediately prior to mixing with asphalt binder. The grading will be determined by Test Method No. Calif. 202, modified by Test Method No. Calif. 905 when there is a difference in specific gravity of 0.2 or more between the coarse and fine portion of the aggregate or between blends of different aggregates.

Evaluation of test results, with moving averages specified, shall conform to the provisions in Section 6-3.02, "Statistical Testing."

39-2.04 Type B Aggregate.—Aggregate for Type B asphalt concrete shall consist of a mixture of coarse and fine aggregate complying with the following requirements:

39-2.04A Coarse Aggregate.—Coarse aggregate shall consist of material of which at least 25 percent by weight shall be crushed particles.

39-2.04B Fine Aggregate.—Fine aggregate shall consist of material containing not less than 20 percent by weight of crushed particles in the portion passing the No. 4 sieve and retained on the No. 8 sieve and the remainder may consist of natural fine aggregate. If filler material is used, it shall conform to the requirements in Section 39-2.03C, "Filler Material."

39-2.04C Grading.—The aggregate for Type B asphalt concrete shall conform to the gradings specified in Section 39-2.02, "Aggregate." Unless otherwise specified in the special provisions, the aggregate shall conform to the grading specified for the 3/4 inch maximum, medium grading.

The combined gradings within the specified limits shall be of such uniformity that the materials during any day's run will not vary more than the following:

Maximum range in the percentage of material passing No. 4 sieve.....	6
Maximum range in the percentage of material passing No. 30 sieve.....	5
Maximum range in the percentage of material passing No. 200 sieve.....	3

The total amount of material passing the No. 200 sieve shall be determined by washing the material in accordance with Test Method No. Calif. 202.

39-2.04D Tests.—The combined aggregate shall also conform to the following quality requirements immediately prior to mixing with asphalt binder:

Tests	Test Method No. Calif.	Requirements
Loss in Los Angeles Rattler (after 500 revolutions) ..	211	50% Max.
Both K _c and K _f -Factors (obtained from Centrifuge Kerosene Equivalent Test)	303	1.7 Max.
Sand Equivalent	217	42 Min. 45 Min.
Individual Test Result	—	—
Moving Average	—	—

Evaluation of test results, with moving averages specified, shall conform to the provisions in Section 6-3.02, "Statistical Testing."

The combined aggregate shall also conform to the following quality requirements when mixed with the amount of asphalt determined to be optimum by Test Method No. Calif. 367:

Tests	Test Method No. Calif.	Requirements
Stabilometer Value ¹	304	35 Min.
Moisture Vapor Susceptibility (Stabilometer Value)	307	25 Min.
Swell	305	0.030" Max.

¹ When the 3/4" Max. or the No. 4 Max aggregate gradings are specified for use, the above Stabilometer Value requirement will be 30 Min.

39-2.05 Type C Aggregate.—Aggregate for Type C asphalt concrete shall consist of a mixture of coarse and fine aggregate complying with the following requirements:

39-2.05A Coarse and Fine Aggregate.—Coarse and fine aggregate shall consist of any one or a mixture of the following materials:

1. Broken or crushed stone, or crushed gravel.

Commercial filler shall consist of portland cement or finely powdered material obtained from crushed rock. The filler material shall be free from lumps, balls, or other deleterious material.

Filler material shall conform to the following requirements immediately prior to mixing:

Tests	Test Method No. Calif.	Requirements
Composition by weight	202	100
Percentage Passing No. 30 Sieve	—	75-100 ¹
Percentage Passing No. 200 Sieve	—	650 Max.
Surface Area (Sq. Ft. per Lb.)	340	2.50 Min.
Specific Gravity	208	—

¹ The quantity of material passing the No. 200 sieve shall be determined by washing the material through the sieve with water. Of the material passing the No. 200 sieve by washing at least one-half of the material shall pass the No. 200 sieve by dry sieving.

39-2.03D Grading.—The aggregate for Type A asphalt concrete shall conform to the grading specified in Section 39-2.02, "Aggregate." Unless otherwise specified in the special provisions, the aggregate shall conform to the grading specified for the 3/4 inch maximum, coarse grading.

The combined gradings within the specified limits shall be of such uniformity that the materials during any day's run will not vary more than the following:

Maximum range in the percentage of material passing No. 4 sieve.....	6
Maximum range in the percentage of material passing No. 30 sieve.....	5
Maximum range in the percentage of material passing No. 200 sieve.....	2

The total amount of material passing the No. 200 sieve shall be determined by washing the material in accordance with Test Method No. Calif. 202.

39-2.03E Tests.—The combined aggregate shall also conform to the following quality requirements immediately prior to mixing with asphalt binder:

Tests	Test Method No. Calif.	Requirements
Loss in Los Angeles Rattler (after 100 revolutions)	211	10% Max.
Loss in Los Angeles Rattler (after 500 revolutions)	211	45% Max.
Both K _c and K _f -Factors (obtained from Centrifuge Kerosene Equivalent Test)	303	1.7 Max.
Sand Equivalent	217	—
Individual Test Result	—	47 Min. 50 Min.
Moving Average	—	—

Evaluation of test results, with moving averages specified, shall conform to the provisions in Section 6-3.02, "Statistical Testing."

The combined aggregate shall also conform to the following quality requirements when mixed with the amount of asphalt determined to be optimum by Test Method No. Calif. 367:

Tests	Test Method No. Calif.	Requirements
Stabilometer Value ¹	304	37 Min.
Moisture Vapor Susceptibility (Stabilometer Value)	307	30 Min.
Swell	305	0.030" Max.

¹ When the 3/4" Max. or the No. 4 Max. aggregate gradings are specified for use, the above Stabilometer Value requirement will be 30 Min.

ASPHALT CONCRETE

SECTION 39

2. Natural material having sufficient roughness to meet the specified stabilometer requirements when combined within the specified limits for grading.

39-2.05B Grading.—The aggregate for Type C asphalt concrete shall conform to the gradings specified in Section 39-2.02, "Aggregate." Unless otherwise specified in the special provisions, the aggregate shall conform to the grading specified for the 3/4 inch maximum, medium grading.

39-2.05C Tests.—The combined aggregate shall also conform to the following quality requirement immediately prior to mixing with asphalt binder:

Tests	Test Method No. Calif.	Requirements
Sand Equivalent	217	
Individual Test Result		32 Min.
Moving Average		35 Min.

Evaluation of test results shall conform to the provisions in Section 6-3.02, "Statistical Testing."

The combined aggregate shall also conform to the following quality requirements when mixed with the amount of asphalt determined to be optimum by Test Method No. Calif. 367:

Tests	Test Method No. Calif.	Requirements
Stabilometer Value	304	30 Min.
Moisture Vapor Susceptibility (Stabilometer Value)	307	20 Min.
Swell	395	0.030" Max.

39-2.06 Aggregate for Open Graded Asphalt Concrete.—Aggregate for Open Graded asphalt concrete shall be clean and free from decomposed materials, vegetable matter, or other deleterious substances.

At least 90 percent by weight of the aggregate shall consist of crushed particles.

39-2.06A Grading.—The percentage composition by weight of aggregate shall conform to one of the following gradings, immediately prior to mixing with asphalt binder, as determined by Test Method No. Calif. 202. Unless otherwise specified in the special provisions, the aggregate shall conform to the grading provided for the 1/4 inch maximum grading.

Sieve sizes	Percentage passing		
	% maximum Individual test result	% maximum Moving average	1/4" maximum Moving average
1/2"	100	100	—
3/8"	88-100	90-100	100
3/4"	—	—	85-100
No. 4	23-42	25-40	—
No. 8	4-22	5-20	5-20
No. 16	0-12	0-10	0-10
No. 300	0-4	0-3	0-3

Evaluation of test results shall conform to the provisions in Section 6-3.02, "Statistical Testing."

39-2.06B Tests.—The combined aggregate shall also conform to the following quality requirements immediately prior to mixing with asphalt binder:

SECTION 39

ASPHALT CONCRETE

Tests	Test Method No. Calif.	Requirements
Loss in Los Angeles Rattler (after 100 revolutions)	211	10% Max.
Loss in Los Angeles Rattler (after 500 revolutions)	211	40% Max.
Film stripping	302	25% Max.
After mixing with asphalt binder.		

39-2.07 Aggregate for Asphalt Concrete Base.—Aggregate for asphalt concrete base shall comply with the specifications for Type A aggregate in Section 39-2.03, "Type A Aggregate," or Type B aggregate in Section 39-2.04, "Type B Aggregate." The type shall be as shown on the plans or designated in the Engineer's Estimate.

The percentage composition by weight of aggregate shall conform to the following grading immediately prior to mixing with asphalt binder as determined by Test Method No. Calif. 202.

Sieve Sizes	Percentage passing	
	Individual test result	Moving average
1 1/2"	100	100
1"	92-100	95-100
3/4"	76-99	80-95
3/8"	46-69	50-65
No. 4	31-54	35-50
No. 30	8-29	12-25
No. 200	0-10	2-7

Evaluation of test results shall conform to the provisions in Section 6-3.02, "Statistical Testing."

39-3 PROPORTIONING AND MIXING MATERIALS

39-3.01 Storage.—Before being fed to the drier, the aggregates shall be separated into sizes and stored as follows:

Aggregate for Type A or Type B asphalt concrete of the 3/4 inch and 1 1/2 inch maximum sizes and asphalt concrete base, shall be separated into 2 or more sizes and stored separately. If the aggregate is separated into only 2 sizes, one storage shall contain material of such size that a minimum of 80 percent will pass a No. 4 sieve and the other storage shall contain material of such size that a minimum of 80 percent will be retained on a No. 4 sieve. If the aggregate is separated into 3 sizes, the third storage, in addition to the above shall contain materials of which either a minimum of 80 percent will be retained on a No. 8 sieve or a minimum of 80 percent will pass a No. 8 sieve. Should the Contractor add natural fine material, he shall provide in addition to the above storages a separate storage for such natural fine material.

Aggregate for Type C asphalt concrete, aggregate for Type A or Type B asphalt concrete of the No. 4 maximum size, and aggregate for Open Graded asphalt concrete of the 1/4 inch maximum size need not be separated into sizes and stored separately.

Aggregates for the 3/8 inch maximum size for Open Graded asphalt concrete and for Type A or Type B asphalt concrete shall be separated into 2 or more sizes and stored separately. If 2 or 3 sizes are used, the sizes shall be separated on screens of such size that the quantity drawn from each storage shall be approximately equal.

If aggregates are separated into more than 3 sizes, any combination of sizes approved by the Engineer that will meet the grading and other test requirements will be acceptable.

When aggregates contain material of which at least 20 percent will pass the No. 8 sieve, the fine material shall be fed to the drier at a uniform rate and the rate of feed shall be maintained within 10 percent of the amount set. Adequate means shall be provided for controlling and checking the accuracy of the feeder.

In placing the materials in storage or in moving them from storage to the mixer, any method which causes segregation, degradation, or the combining of materials of different gradings shall be discontinued and the segregated or degraded material shall be rescreened or wasted.

39-3.02 Drying.—Aggregates shall be dried by means of a drier, which is evenly fed by any combination of belts, conveyors, bucket elevators, bunkers, tunnels, or silos, except that aggregates for Type C asphalt concrete may be mixed and evenly fed to the drier by any method the Contractor elects.

Drying shall continue for a sufficient time and at a sufficiently high temperature to reduce the average moisture content so that at the completion of mixing operations and also at the time of spreading the mixture, the amount of moisture in the mixture shall not exceed one percent as determined by Test Method No. Calif. 311.

The drier shall be provided with a heat indicating device in order that the temperature of the aggregate leaving the drier may be determined. The heat indicating device shall be accurate to the nearest 10° F., and shall be installed in such a manner that a fluctuation of 10° F. in the aggregate temperature will be shown by the heat indicating device within one minute.

39-3.03 Proportioning.—After being dried, aggregates for Type A, Type B, and Open Graded asphalt concrete and asphalt concrete base shall be separated into sizes, stored in separate bins and proportioned in accordance with the following.

Aggregate of the 3/4 inch or 1/2 inch maximum size and aggregate for asphalt concrete base shall be separated into 3 or more sizes and each size shall be stored in separate bins. If 3 sizes are used, one bin shall contain that portion of the material which will pass the maximum size specified and be retained on a 3/8 inch sieve; one bin shall contain that portion of the material which will pass a 3/8 inch sieve and be retained on a No. 8 sieve; and one bin shall contain that portion of the material which will pass a No. 8 sieve.

Aggregate of 3/8 inch maximum size shall be separated into 2 sizes and each size shall be stored in separate bins. One bin shall contain that portion of the material which will pass the maximum size specified and be retained on a No. 8 sieve and one bin shall contain that portion of the material which will pass a No. 8 sieve.

The bin containing the fine material shall not contain more than 15 percent of material retained on the No. 8 sieve. The material in any of the other bins shall not contain more than 15 percent of material passing a No. 8 sieve. Failure to comply with this requirement shall be corrected immediately, and the material in the bins not meeting these requirements shall be rescreened or wasted.

Aggregate for Open Graded asphalt concrete shall be separated into 2 or more sizes and each size shall be stored in separate bins. If aggregate is separated into 2 sizes, the quantity of aggregate in any bin shall not be less than 30 percent of the total quantity of the aggregate in the bins. If aggregate is separated into more than 2 sizes, the quantity of the aggregate in any bin shall not be less than 20 percent of the total quantity of the aggregate in the bins. The screen sizes used to separate the aggregate for storage shall be selected by the Contractor. No bin shall contain more than 10 percent of the material which is retained on the larger screen nor more than 10 percent of material which will pass the smaller screen.

Storage bins shall be provided with outside chutes to prevent overflow into adjacent bins.

When filler material is used, it shall be added to the mixer separately and shall be thoroughly dry. If the materials are mixed in a batching plant, the filler material shall be fed directly into the mixer as near the center as possible. The amount of filler material shall be determined by weighing on springless dial scales separate from the plant weigh hopper or by some method that uniformly feeds the mixer within 10 percent of the required amount.

If the materials are mixed in a continuous mixing plant the filler material shall be introduced in the mixer as provided in Section 39-3.04D, "Continuous Mixing."

The exact proportions of aggregate and the amount of asphalt binder for each type of mixture shall be regulated as directed by the Engineer to produce a satisfactory mixture.

39-3.04 Mixing.—Aggregates and asphalt binders shall be mixed in conformity with the following:

39-3.04A General Requirements.—Asphalt concrete shall be mixed at a central mixing plant by either batch mixing or continuous mixing at the option of the Contractor. The aggregates and asphalt binder may be proportioned either by weight or by volume.

Uniformity of distribution of asphalt will be determined by extraction tests in accordance with Test Method No. Calif. 310. The bitumen ratio (pounds of asphalt per 100 pounds of dry aggregates) shall not vary by more than 5 percent above or 10 percent below the amount designated by the Engineer. This requirement shall apply to samples taken from a single batch, successive batches, at different locations in the pug mill of batch type plants, at different locations in the output of continuous type plants, or at any other location or operation designated by the Engineer.

Except for mixing Type C asphalt concrete, mixing plants shall be provided with a dust collector. The dust collector system shall be equipped to collect and return uniformly to the mixer all or a portion of the material so collected as the Engineer may direct.

The weight of charge in a batch mixer, or the rate of feed to a continuous mixer, shall not exceed that which will permit complete mixing of all of the material. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected either by a reduction in the volume of material or by other adjustments.

Paving asphalt used as binder shall be added to the aggregate at a temperature of not less than 250° F., nor more than 375° F.

When paving asphalt is used as a binder, the temperature of the aggregates at the time of adding the binder shall not be less than 250° F., nor more than 325° F.

Liquid asphalt used as binder shall be added to the aggregate at a temperature conforming to the range of temperatures provided in Section 93-1.03, "Mixing and Applying," for distributor application of the grade of liquid asphalt being used.

When liquid asphalt is used as a binder, the temperature of the aggregates at the time of adding the binder shall not be in excess of the applicable mixing temperature provided for pugmill mixing in Section 93-1.03, "Mixing and Applying."

Asphalt storage tanks shall be accurately calibrated to 100-gallon intervals and maintained to this accuracy. They shall be made accessible for measuring the volume of asphalt at any time.

ASPHALT CONCRETE

SECTION 39

The Contractor shall provide in the asphalt feed lines connecting the plant storage tanks to the asphalt weighing system or spray bar, a suitable sampling outlet. The sampling device shall consist of a 1/2 inch or 3/4 inch valve constructed in such a manner that a one-quart sample may be withdrawn slowly at any time during plant operations. The valve shall be maintained in good condition and if it fails to function properly, it shall be replaced. The sampling device shall be placed in a location that is readily accessible and in an area free of dangerous obstructions. A drainage receptacle shall be provided for flushing the device prior to sampling.

The discharge end of the asphalt binder circulating pipe shall be maintained below the surface of the asphalt binder in the storage tank to prevent discharging hot asphalt binder into open air. A temperature indicating device reading to 500° F. and accurate to 10° F. shall be fixed in the asphalt line at a suitable location.

All boxes, hoppers, buckets, or like receptacles used for measuring aggregate, filler material and asphalt binder, together with the scales or metering device of any kind used in batching materials, shall be so insulated against movement of the rest of the plant, due to any operating equipment, that the error in weighing with the entire plant running will not exceed 3 percent for any setting nor exceed 2 percent for any batch. The Contractor shall furnish scales and a 50-gallon tank for use in testing metering devices.

39-3.04B Batch Mixing.—In addition to the "General Requirements" as provided in Section 39-3.04A, batch mixing of the materials shall conform to the following requirements.

The mixer shall be equipped with a sufficient number of paddles of a type and arrangement to produce a properly mixed batch as specified in this Section 39-3.04B.

The binder shall be introduced uniformly into the mixer along the center of the mixer parallel to the mixer shafts, or by pressure spraying. When a pan is used it shall be equipped with movable vanes in order that the flow of binder may be directed across the width of the pan, as desired. The vanes shall be equipped with a means for quick adjustment, and a positive lock to prevent shifting.

The mixer platform shall be of ample size to provide safe and convenient access to the mixer and other equipment. The mixer housing and weigh box housing shall be provided with gates of ample size to permit ready sampling of the discharge of aggregate from each of the plant bins and of the mixture from each end of the pugmill.

The mixer shall be equipped with a timing device which will indicate by a definite audible or visual signal the expiration of the mixing period. The device shall measure the time of mixing within an accuracy of 2 seconds. A suitable automatic device for counting the number of batches shall be provided and maintained in proper working condition.

The time of mixing a batch shall begin on the charging stroke of the weigh hopper dumping mechanism and shall end when discharge is started. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly coated aggregates of unchanging appearance is produced. In general, the time of mixing shall not be less than 30 seconds, except that the time may be reduced when in the opinion of the Engineer the sizes of aggregate are uniformly distributed and all particles are thoroughly and uniformly coated with asphalt binder.

SECTION 25
AGGREGATE SUBBASES

25-1.01 Description.—This work shall consist of furnishing, spreading and compacting aggregate subbases as specified in these specifications and the special provisions.

Aggregate subbases are designated as Class 1, Class 2, Class 3, Class 4, and Class 5. The class of aggregate subbase will be shown on the plans or specified in the special provisions.

25-1.02 Materials.—Aggregate for the various classes of aggregate subbases at the time it is deposited on the roadbed shall conform to the following requirements:

25-1.02A Class 1, Class 2, and Class 3 Aggregate Subbases.—Aggregate for Class 1, Class 2, and Class 3 aggregate subbases shall be clean and free from vegetable matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable base.

The percentage composition by weight of Class 1, Class 2, or Class 3 aggregate subbases shall conform to the grading shown in the following table for the class specified when determined by Test Method No. Calif. 202.

Percentage Passing

Sieve Sizes	Class 1		Class 2		Class 3	
	Individual Test Result	Moving Average	Individual Test Result	Moving Average	Individual Test Result	Moving Average
3"	100	100	100	100	100	100
2 1/4"	87-100	90-100	87-100	90-100	87-100	90-100
No. 4	30-75	35-70	35-95	40-90	45-100	50-100
No. 200	0-23	0-20	0-29	0-25	0-34	0-30

Class 1, Class 2, and Class 3 aggregate subbases shall also conform to the quality requirements shown in the following tables for the class specified.

Requirements

Tests	Class 1		Class 2		Class 3	
	Individual Test Result	Moving Average	Individual Test Result	Moving Average	Individual Test Result	Moving Average
Sand	Method No. Calif.		Method No. Calif.		Method No. Calif.	
Equivalent ...	217	18 Min.	21 Min.	18 Min.	21 Min.	21 Min.
Resistance						
(R-value) ¹ ...	301	60 Min.	—	50 Min.	—	40 Min.

¹ The R-value requirement will be waived provided the individual test result of the aggregate subbase has a Sand Equivalent value of 25 or more, except that the R-value requirement will not be waived for aggregates which have been treated with lime, cement or other chemical material.

Evaluation of test results, with moving averages specified, shall conform to the provisions in Section 6-3.02, "Statistical Testing."

25-1.02B Class 4 Aggregate Subbase.—Aggregate for Class 4 aggregate subbase shall be clean and free from vegetable matter and other deleterious substances and shall conform to the grading and quality requirements set forth in the special provisions.

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AGGREGATE SUBBASES

25-1.02C Class 5 Aggregate Subbase.—Aggregate for Class 5 aggregate subbase shall be selected from excavation at the locations designated on the plans or in the special provisions and processed to the grading specified in the special provisions.

The Contractor may break up, crush, screen, waste material or any combination thereof, or use any other process he elects that will produce the required grading.

All excess material resulting from processing shall be used in the construction of embankments or otherwise disposed of within the right of way as directed by the Engineer and full compensation therefor will be considered as included in the contract prices paid for excavation and overhaul. Overhaul for such excess material shall be measured from the original location of the material in excavation to its final location and no additional compensation will be allowed for circuitous haul or additional handling.

25-1.03 Grade Tolerance.—The subgrade to receive aggregate subbase, immediately prior to spreading, shall conform to the compaction and elevation tolerance specified for the material involved and shall be free of loose or extraneous material.

Preparation of subgrade for aggregate subbase to be paid for by the ton will not be required, provided the following conditions are complied with:

(1) The material placed immediately below the grading plane conforms to all the requirements for the class of aggregate subbase specified in the special provisions.

(2) No material of any kind shall project above the grading plane at the time placement of aggregate subbase material is started.

(3) The pay quantity of aggregate subbase will be the planned volume, adjusted by the amount of any authorized changes, as determined by the Engineer from the dimensions shown on the plans and such volume will be converted to weight measurement. The factor for conversion from volume to weight will be determined by the Engineer, and the Contractor shall agree to the use of such factor prior to furnishing and placing aggregate subbase.

(4) No compensation will be allowed for additional aggregate subbase placed by reason of the grading plane being lower than the grade established by the Engineer.

When aggregate subbase is paid for by the cubic yard, areas of the grading plane which are lower than the grade established by the Engineer may be filled with aggregate subbase. Volumes of aggregate subbase so placed will not be included in the volume calculated for payment. If basement material consists of imported borrow, subbase placed below the grading plane as specified will not be measured or paid for as imported borrow.

25-1.04 Spreading.—Aggregates for subbases shall be delivered to the roadbed as uniform mixtures and shall be spread in layers or windrows. Segregation shall be avoided and the subbase shall be free from pockets of coarse or fine material.

The aggregate subbase after spreading as above specified shall be shaped to such thickness that after watering and compacting, the completed subbase will conform to the required grade and cross section within the tolerance specified in Section 25-1.05, "Compacting."

When the subgrade for aggregate subbases consists of cohesionless sand, and written permission is granted by the Engineer, a portion of the aggregate subbase may be dumped in piles upon the subgrade and spread ahead in sufficient quantity

AGGREGATE SUBBASES

to stabilize the subgrade. Segregation of aggregates shall be avoided and the material as spread shall be free from pockets of large or fine material.

Where the required thickness is 0.50-foot or less, the aggregate subbase may be spread and compacted in one layer. Where the required thickness is more than 0.50-foot, the aggregate subbase shall be spread and compacted in 2 or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 0.50-foot. Each layer shall be spread and compacted in a similar manner.

At locations where the aggregate subbase is to be placed over areas inaccessible to the spreading equipment, the aggregate subbase may be spread and compacted by any means to obtain the specified results.

25-1.05 Compacting.—Aggregate subbases shall be watered as provided in Section 17, "Watering."

The relative compaction of each layer of compacted subbase material shall not be less than the following percent as determined by Test Method No. Calif. 216.

Individual Test Result	92
Moving Average	95

Evaluation of test results shall conform to the provisions in Section 6-3.02, "Statistical Testing."

When aggregate subbase is not to be covered, or it is to be covered by material which is paid for by the ton, the surface of the finished subbase at any point shall not vary more than 0.08-foot above or below the grade established by the Engineer.

When aggregate subbase is to be covered by material which is paid for by the cubic yard, the surface of the finished subbase shall not project above the grade established by the Engineer at any point. At locations where the planned thickness of aggregate subbase, less allowable tolerance, is not obtained and is not compensated for by an equivalent thickness of aggregate base or cement treated base, the Contractor shall take such corrective measures as are necessary to obtain said thickness. If requested by the Contractor and permitted by the Engineer, a deduction will be made from contract payment for aggregate subbase in lieu of correcting the deficient thickness. Such deduction will be computed as the product of (a) the deficient thickness less allowable tolerance; (b) the planned width; and (c) the longitudinal distance between locations showing specified thickness, all as determined by the Engineer, multiplied by a fixed price of \$4.00 per cubic yard, or the contract bid price, whichever is higher.

Subbase which does not conform to the above requirements shall be reworked, watered and thoroughly recompact to conform with the specified requirements.

SECTION 26

AGGREGATE BASES

26-1.01 Description.—This work shall consist of furnishing, spreading and compacting aggregate bases as specified in these specifications and the special provisions.

Aggregate bases are designated as Class 2 and Class 3. The class of aggregate base will be shown on the plans or specified in the special provisions.

The combined aggregate shall conform to the grading specified for the 3/4 inch maximum aggregate for Class 2 aggregate base, unless otherwise specified in the special provisions.

26-1.02 Materials.—Aggregate for the various classes of aggregate base at the time it is deposited on the roadbed shall conform to the following requirements:

26-1.02A (Blank)

26-1.02B Class 2 Aggregate Base.—Aggregate for Class 2 aggregate base shall be free from vegetable matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable base.

The coarse aggregate (material retained on the No. 4 sieve) shall consist of material of which at least 25 percent by weight shall be crushed particles as determined by Test Method No. Calif. 205.

The percentage composition by weight of aggregate base shall conform to one of the following gradings when determined by Test Method No. Calif. 202, modified by Test Method No. Calif. 905 when there is a difference in specific gravity of 0.2 or more between the coarse and fine portion of the aggregate or between blends of different aggregates.

Sieve Sizes	Percentage Passing		
	1 1/2" Maximum Individual Test Results	Moving Average	3/4" Maximum Individual Test Results
2"	100	100	—
1 1/2"	87-100	90-100	—
1"	—	—	100
3/4"	45-90	50-85	87-100
No. 4	20-50	25-45	30-60
No. 30	6-29	10-25	5-35
No. 200	0-12	2-9	0-12

The aggregate base shall also conform to the following quality requirements:

Tests	Test Method No. Calif.	Requirements	
		Individual Test Result	Moving Average
Resistance (R-value) ¹	301	78 Min.	—
Sand Equivalent	217	28 Min.	31 Min.
Durability Index	229	35 Min.	—

¹The R-value requirement will be waived provided the individual test result of the aggregate base conforms to the specified grading and durability and has a Sand Equivalent value of 35 or more except that the R-value requirement will not be waived for aggregates which have been treated with lime, cement or other chemical material.

Evaluation of test results, with moving averages specified, shall conform to the provisions in Section 6-3.02, "Statistical Testing."

The aggregate shall not be treated with lime, cement or other chemical material before the Durability Index test is performed.

26-1.02C Class 3 Aggregate Base.—Aggregate for Class 3 aggregate base shall conform to the requirements set forth in the special provisions.

26-1.03 Grade Tolerance.—The subgrade to receive aggregate base, immediately prior to spreading shall conform to the compaction and elevation tolerance specified for the material involved, and shall be free of loose or extraneous material.

When aggregate base is paid for by the cubic yard, areas of the finished surface of aggregate subbase which are lower than the grade established by the Engineer shall be filled with aggregate base. Volumes of aggregate base so placed will not

When aggregate subbase is not specified and aggregate base is paid for by the cubic yard, areas of the grading plane which are lower than the grade established by the Engineer may be filled with aggregate base. Volumes of aggregate base so placed will not be included in the volume calculated for payment as stated above. If basement material consists of imported borrow, aggregate base placed below the grading plane as specified will not be measured or paid for as imported borrow.

26-1.035 Adding Water.—At the time aggregate base is spread it shall have a moisture content sufficient to obtain the required compaction. Such moisture shall be uniformly distributed throughout the material.

26-1.04 Spreading.—Aggregate bases shall be delivered to the roadbed as uniform mixtures and each layer shall be spread in one operation. Segregation shall be avoided and the base shall be free from pockets of coarse or fine material.

Aggregate bases shall be deposited on the roadbed at a uniform quantity per linear foot, which quantity shall provide the required compacted thickness within the tolerances specified in Section 26-1.05, "Compacting," without resorting to spotting, picking-up or otherwise shifting the aggregate base material.

Where the required thickness is 0.50-foot or less the base material may be spread and compacted in one layer. Where the required thickness is more than 0.50-foot, the base material shall be spread and compacted in 2 or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 0.50-foot. Each layer shall be spread and compacted in a similar manner.

Aggregate bases, placed on road approaches and connections, street intersection areas, median strip areas, shoulder areas, and at locations which are inaccessible to the spreading equipment, may be spread in one or more layers by any means to obtain the specified results.

When the subgrade for aggregate base consists of cohesionless sand, and written permission is granted by the Engineer, a portion of the aggregate base may be dumped in piles upon the subgrade and spread ahead from the dumped material in sufficient quantity to stabilize the subgrade. Segregation of aggregate shall be avoided and the material as spread shall be free from pockets of coarse or fine material.

26-1.05 Compacting.—Aggregate bases, after compaction, shall be watered as provided in Section 17, "Watering."

The relative compaction of each layer of compacted base material shall not be less than the following percent as determined by Test Method No. Calif. 216:

Individual Test Result	92
Moving Average	95

Evaluation of test results shall conform to the provisions in Section 6-3.02, "Statistical Testing."

The surface of the finished aggregate base at any point shall not vary more than 0.05-foot above or below the grade established by the Engineer.

When aggregate base is paid for by the cubic yard, and at locations where the planned thickness of aggregate base, less allowable tolerance, is not obtained, the Contractor shall take such corrective measures as are necessary to obtain said thickness. If requested by the Contractor and permitted by the Engineer, a deduction will be made from contract payment for aggregate base in lieu of correcting the deficient thickness. Such deduction will be computed as the product of (a) the deficient thickness less allowable tolerance; (b) the planned width; and (c) the longitudinal distance between locations showing specified thickness, all as determined by the Engineer, multiplied by a fixed price of \$7.00 per cubic yard, or the contract bid price, whichever is higher.

Base which does not conform to the above requirements shall be reshaped or reworked, watered and thoroughly recompact.

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